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ABSTRACT

Foundational Approaches in Science Teaching (FAST) is an interdisciplinary environmental science program which emphasizes the foundational concepts and methods of the physical, biological, and earth sciences, and relates these concepts to issues about the human use of the environment. This document stresses that evaluation is an integral part of the FAST program, and it discusses both formal and informal evaluation mechanisms used by teachers to monitor student progress. Students also are involved in evaluating their own progress through a self-evaluation mechanism which is built into the program. The guide: (1) defines evaluation, for the purposes of the program; (2) describes the functions of evaluation, using several examples of both teacher and student evaluations; (3) explains the FAST instructional system; and (4) delineates the components of the evaluation system used in the FAST program. The last and longest section of the guide consists of the evaluation instruments used in the Physical Science and Ecology strands of FAST 1, the local environment component of the FAST program, along with suggestions for preparing, organizing and assessing each evaluation. (TW)

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Evaluation Guide

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FAST I

Four-Year Research Project in Science Teaching
Center for Research and Development Group
University of Hawaii

ED 275 543

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PREFACE

Foundational Approaches in Science Teaching (FAST) is an interdisciplinary, environmental science program which emphasizes the foundational concepts and methods of the physical, biological, and earth sciences, and relates these concepts to the practical issues of human use of the environment. FAST involves students directly in the operations of research, invention, evaluation, and decision making. Approximately 60 to 80 percent of class time is spent on investigations in the field and laboratory. The remaining 20 to 40 percent of time is devoted to discussion, reports, and analysis of data.

A research team model is used for class organization. Group interaction in planning, execution of investigations, discussions, validation of hypotheses, and simulation are central to the FAST system of instruction. The teacher acts as a research director-facilitator by maintaining an atmosphere of challenge, setting tasks, asking questions, giving suggestions for further investigations, and assisting students to evaluate their outputs and competencies. The teacher is the facilitator of group involvement. The student is the producer of information. In many FAST sequences, students are engaged in the full scope of research activities. They must identify the nature of the problem that they are dealing with, formulate hypotheses, design and carry out experiments, and report their findings for the critical review of their peers.

Evaluation is an integral part of the FAST program. Evaluation processes have been carefully designed for incorporation throughout the program and involve both the teacher and student. The teacher uses both formal and informal evaluation mechanisms to monitor student progress. Formal evaluation includes test instruments to evaluate student progress. Students are also involved in evaluating their own progress through a self-evaluation mechanism which is built into the program. This guide describes the FAST Instructional System, the evaluation components of the system, and includes instruments to be used by teachers and students.

Francis M. Pottenger III
Co-Director

Donald B. Young
Co-Director

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DEFINITION OF EVALUATION

Evaluation, as used in the FAST program, refers to both informal and formal methods which teachers and students use to estimate, measure, and form value judgments about student learning. Evaluation is broader than mere measurement. Evaluation includes teacher observation of student actions in class, teacher dialogue with students, assessment of homework assignments, and performance in laboratory and field activities. It includes assessment through written work, notebooks, quizzes, and tests as well as interaction with and interpretation of students' own assessment of their work.

We believe that the study of science can make important contributions to the growth of the intellect. In FAST this implies the following kinds of instruction, each of which has an evaluation component:

1. Engaging students in laboratory and field experiences which require the students to obtain and interpret information.

2. Engaging students in conversations and discussions through questioning strategies which cause students to develop and practice patterns of logical thinking.

3. Engaging students in developing and practicing oral and written communication skills.

4. Engaging students in developing and practicing skills of self-evaluation.

5. Monitoring changes in student development of concepts and skills, and adjusting instructional strategies to build on actual progress.

6. Reporting of personal assessment of student progress to the student, school, and parents.

All of these activities directly or indirectly involve systematic evaluation of student progress.

FUNCTIONS OF EVALUATION

There are three major kinds of evaluation suggested for the FAST program: (1) diagnostic-prescriptive, (2) student self-evaluation, and (3) certification. Each of these is described below.

1. Diagnostic-Prescriptive Evaluation

One function of evaluation is to identify areas of student difficulty with coursework. Such evaluation is used to assist the teacher in planning future learning activities. This use of evaluation is referred to as "diagnostic-prescriptive" evaluation.

Diagnostic-prescriptive evaluation has three principal components, each with its own set of purposes. These are: (a) teacher assessment of group progress, (b) teacher assessment of individual student progress, and (c) prescription.

a. Teacher assessment of group progress helps to determine

1) the degree of group mastery of concepts and skills.

2) the degree of development of desired attitudes.

3) the particular topics, activity, project, etc., that should be used in the next series of learning activities.

4) the pace at which the class can move from topic to topic, or from unit to unit.

5) the method of presentation best used for class activities.

b. Teacher assessment of the individual student's progress helps to determine

1) the degree of a student's mastery of concepts and skills.

2) the degree of a student's development of desired attitudes.

3) what steps need to be taken by a student to master concepts and skills not yet mastered.

4) which activities will extend a student's mastery of skills and concepts.

5) methods that might be helpful in shaping program encounters appropriate to a student's personal style of learning.

c. Prescription

The FAST sequence of content within units is designed in a spiral fashion so that any skill or concept, once introduced, is regularly

reintroduced and used in different contexts. This gives the teacher a built-in mechanism for prescribing new tasks at each encounter for dealing with diagnosed weaknesses. The steps involved in prescription are:

Step 1: Identify real or felt deficiency on the part of the student. This can be done by using various informal evaluation techniques, formal testing, or the student's own self-evaluation.

Step 2: Refer to the Teacher's Guide or Student Book and locate the point at which the skill or concept is to be used again.

Step 3: Give differential assignment of tasks to research groups to insure that a student or students with a deficiency personally confronts the deficiency in the next sequence. At the time of reinvolvement, observations and personal interaction on the part of the teacher will normally help the students to overcome their deficiencies.

In most cases, concepts and skills will be mastered by the end of the course. Basic concepts and skills are so frequently recycled throughout the program that most students will ultimately master them simply as a result of the intensive and constant re-exposure.

2. Student Self-Evaluation

Student self-evaluation is included in the FAST program to help students become

a. independent processors and generators of knowledge.

b. aware of their own learning capacities.

c. confident of their abilities to act independently.

d. better able to make rational decisions about personal potential.

e. capable of seeking knowledge through their own activities.

f. capable of diagnosing their own deficiencies and initiating their own remediation program.

3. Certification Evaluation

Certification evaluation is a required component of schooling and generally serves two interest groups, (a) the school and (b) the public.

a. School interest in certification evaluation is satisfied by

1) indicating to other teachers and/or schools the relative progress of a student in a given subject area.

2) determining the future choice of coursework open to the student.

3) determining whether a student shall pass from grade to grade and/or graduate from the school.

4) acting as a motivation to students (positive and/or negative).

5) rewarding students for satisfactory or meritorious work and accomplishments.

6) seeking parental assistance or other means to stimulate students whose work is deemed less than satisfactory.

b. Public interest in certification evaluation is satisfied by

1) informing parents or guardians of the student's progress or lack of progress.

2) indicating to hiring or other interested agencies the "achievement" of the student at a given time.

Though some of the purposes of certification evaluation may be undesirable, they do exist in the operations of schools and in the minds of students, parents, and the community. For this reason, considerable thought should be given to deciding on the form of reporting the results of evaluation.

FAST INSTRUCTIONAL SYSTEM

Instruction in FAST involves the interaction of three principle elements: the teacher, the student, and the FAST program. The interaction of these elements provides the operations of instruction which can be grouped into three broad categories: operations of teacher-controlled instruction, operations of student-controlled instruction, and operations of evaluation.

1. Teacher-Controlled Instruction

The initiator of instruction is usually the teacher who plans and manages the student encounter with the program. An encounter may take the form of an experiment, discussion, reading or writing assignment, or any other activity that enables students to progress towards achievement of teacher, program, or school objectives.

An effective encounter will in some way change the student, and such change constitutes learning. Evidence of the success and quality of learning is found in the capacity of the student to make some set of desired responses. These responses may be evidenced at the time of the encounter or in some later writings, dialogue, or formal testing.

Direct or indirect teacher-student interaction through encounter and response is the heart of the instructional system. This is described diagrammatically in Figure 1. The boxes represent the student and the teacher, the ovals represent activities, and the arrows represent interaction.

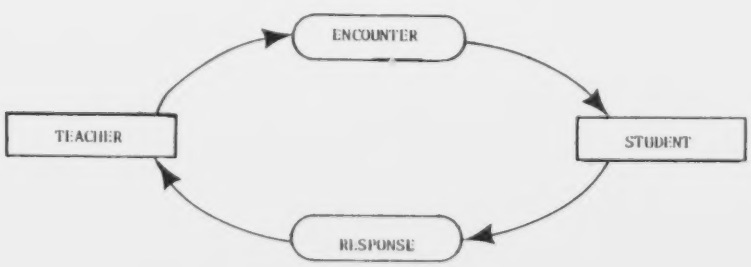

Figure 1 The student-teacher encounter-response cycle.

In some cases the teacher arranges for another student, a group, or the entire class to operate as a surrogate by taking on instructional roles through structured group discussions, simulations, etc. The surrogate role may also be spontaneous, as when a fellow student asks a question, challenges an idea, asks for validation, etc., and thereby creates an unanticipated encounter. The surrogate role is shown in Figure 2.

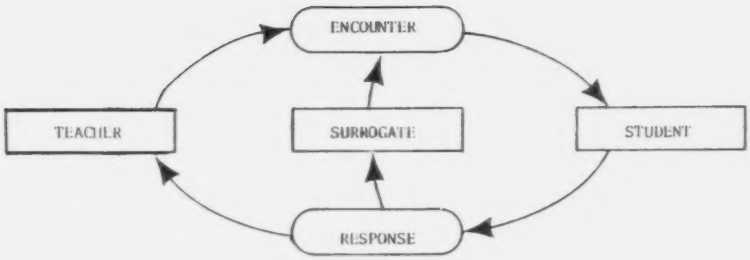

Figure 2 The role of surrogate in teacher-controlled instruction.

In developing the daily sequence of encounters, the teacher should analyze student responses to preceding work in the light of the catalog of suggestions included in the FAST student materials and Teacher's Guide. These suggestions provide a strategy for follow-up activities which can then be shaped into the next series of encounters. A simple diagram of this sequence of operations of teacher-controlled instruction is shown in Figure 3.

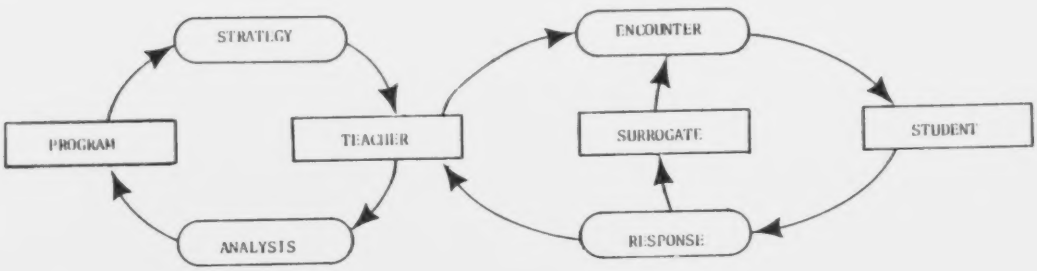

Figure 3 Teacher-controlled instruction.

2. Student-Controlled Instruction

Ideally, in FAST the responsibility for learning should fall more and more on the student as the year progresses. FAST is so designed that the materials provide many sequences where the student can control instruction with minimal direction from the teacher. The intent of these sequences is to develop the capacity for self-directed inquiry. The student-controlled instruction cycle is shown in Figure 4.

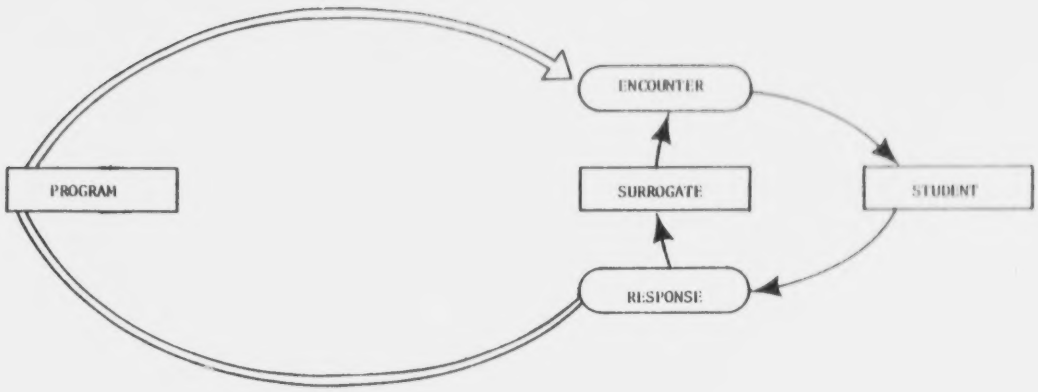

Figure 4 Student-controlled instruction.

Aiding students are the Student Book, Student Record Book, Reference Booklets, and suggested lists of outside resources.

3. Role of Evaluation in the FAST Instructional System

The third major set of operations involves evaluation. Ideally all student responses should be subject to both teacher and student evaluation. Response evaluation is used here to refer to a judgment made of the nature of a student's response during the instructional encounter. It is intended that such evaluation should be used to shape later encounters of students with the FAST program.

In FAST every effort should be made to actively engage the student in evaluation. There are several reasons for student involvement. First, for students to become independent seekers and producers of knowledge, they must be able to assess the limits of their own knowledge and the quality of their own responses. Second, a teacher can best aid the individual student when both parties know which concepts and skills have or have not yet been mastered. Since formal testing is at best a partial indicator of a student's learning, it is important for the student to make an independent, explicit assessment of personal proficiencies and deficiencies.

Teacher evaluation of the student, in the judgmental sense used here, is the central link that binds the program and student together. In the teacher-controlled instructional cycle the analysis of student response leads to the shaping of new encounters. The analysis is diagnostic and the strategies are prescriptive. In the ongoing classroom, individual student responses are immediately evaluated by the teacher in the evolving dynamics of the day's encounters. To the student this kind of evaluation is implicit. In such cases the teacher goes on to the next topic (all is well), uses a student's idea (good work), devises an alternative idea (work is questionable), etc.

Explicit teacher evaluation is also essential to the FAST program. It may take a range of forms. At the most informal level, student-teacher dialogue; at the most formal level, evaluated tests. Explicit teacher evaluation reduces ambiguity as to what the teacher perceives is and is not known by the student. It facilitates remediation of deficiencies as well as gives a sense of achievement to the student who has mastered some set of concepts or skills.

Separate from the diagnostic and prescriptive types of evaluation just mentioned is the explicit evaluational statement in the school record. Though it flows out of the same informational base as other evaluations, its purpose is often quite different, usually acting as a graded certification of performance over some extended work period in the form of a report card.

The relationships of the evaluation cycles of students and teacher are shown in Figure 5.

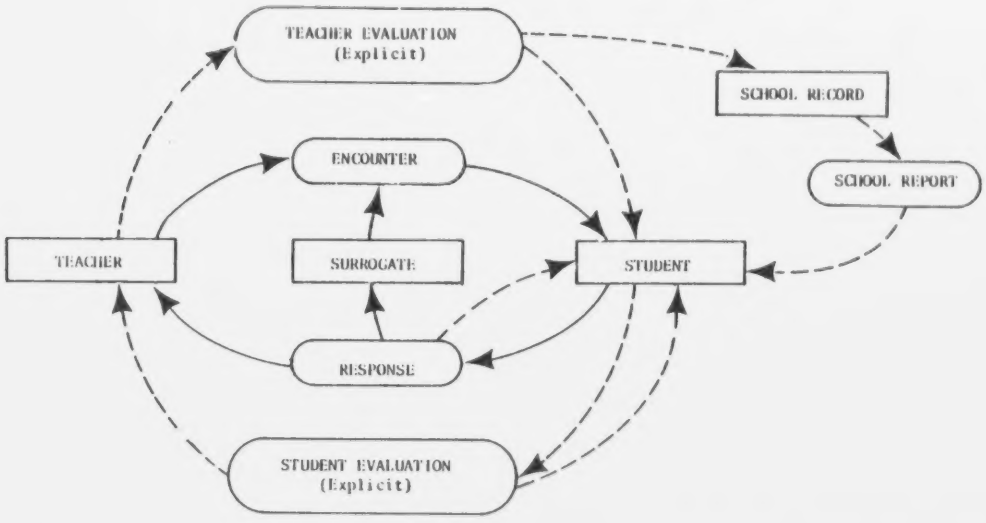

Figure 5 Responses evaluated by teacher and student.

Putting the three operations of instruction (teacher-controlled instruction, student-controlled instruction, and evaluation) together, they produce the FAST Instructional System as shown in Figure 6.

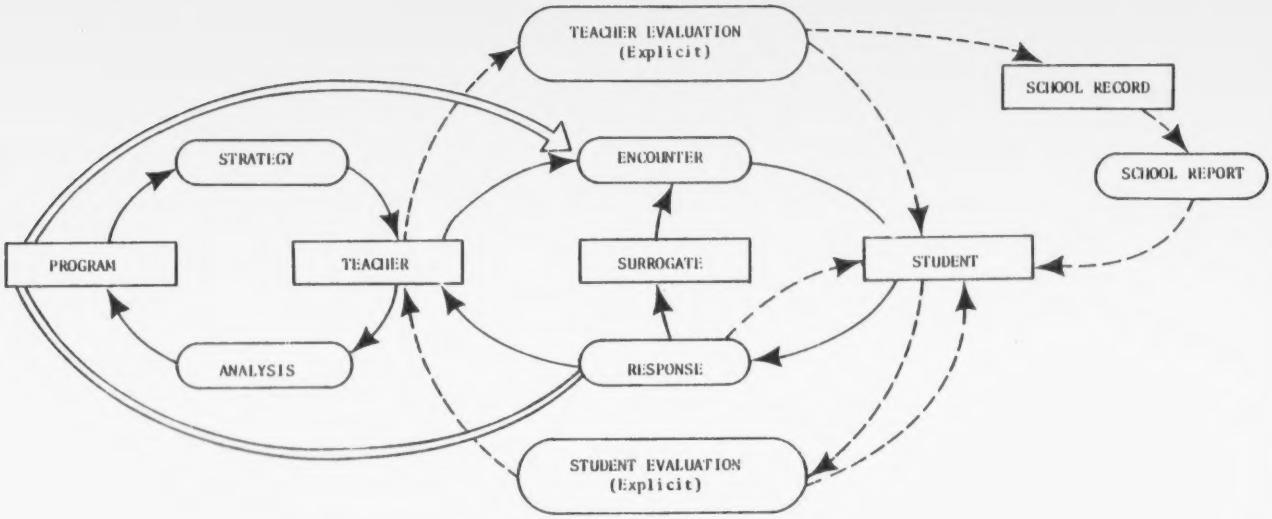

Figure 6 The FAST Instructional System.

FAST EVALUATION SYSTEM

In order to make the operations of evaluation as objective and comprehensive as possible, FAST uses an evaluation system that integrates both informal and formal mechanisms. Each evaluation mechanism is keyed to or reflected in one of the other components. For example, formal test instruments are keyed to the concepts and skills tested in the Class Progress Record, which acts as a diagnostic record of mastery. The Class Progress Record in turn is keyed to the student's self-evaluation called the Student Progress Record. The informal mechanisms of evaluation are also reflected in the Student Progress Record and final teacher evaluation record. This relationship among the components of the FAST Evaluation System can be diagramed as shown in Figure 7. In addition to these components there may be teacher-initiated evaluation techniques not specifically included in FAST such as quizzes, student projects on related topics, group presentations, etc., which are commonly used in evaluating student achievement and progress.

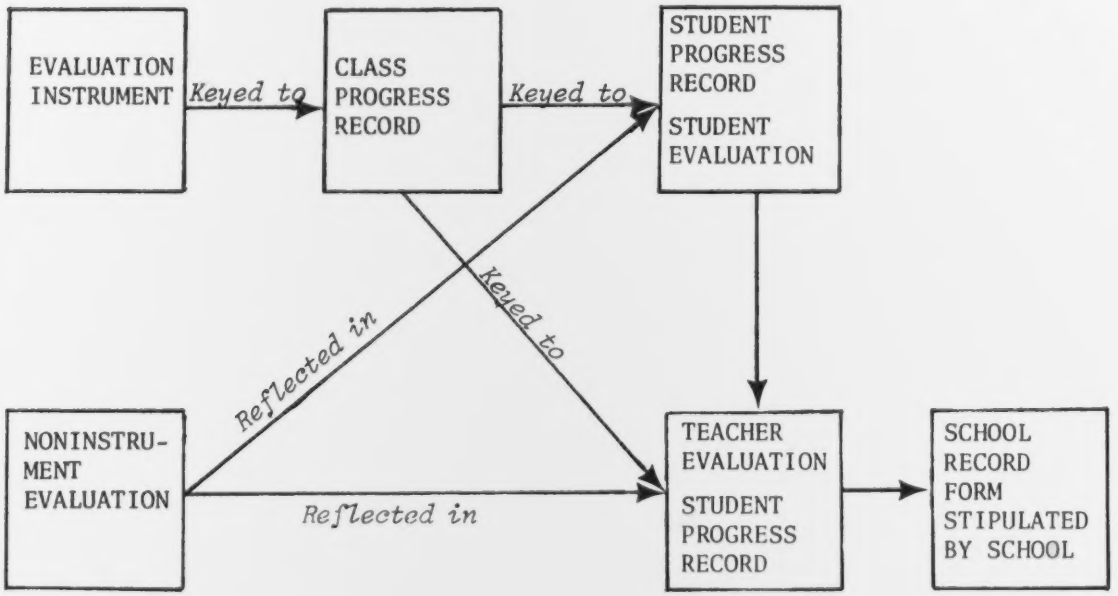

Figure 7 The components of FAST Evaluation System.

Components of the FAST Evaluation System

In FAST there are four primary components of evaluation. These include (1) noninstrument evaluation, (2) FAST evaluation instruments, (3) the Class Progress Record, and (4) the Student Progress Record.

1. Noninstrument Evaluation

Ideally, all responses of students to instruction should be evaluated. In reality, with 20 to 30 students per class, it is impossible for the teacher to attain such a goal. At best, the evaluation can include but a sampling of student responses. There are two kinds of noninstrument evaluation, informal and formal.

a. Noninstrument Informal Evaluation: There are a number of opportunities in the FAST classroom for teachers to assess student progress in an informal subjective way. These include the following:

1) Student participation and/or response in class discussion.

2) Class report presentation.

3) Participation as a team member.

4) Execution of directions in both lab and field experiments.

5) Insightfulness in interpretation of experimental results.

6) Inventiveness in design of devices and experiments.

7) Capacity to solve problems involving unknowns.

8) Mastery of self-evaluation skills.

9) Insight in application of knowledge to social, economic, and political problems.

10) Ability to teach fellow students.

b. Noninstrument Formal Evaluation: Specific evaluational techniques have been incorporated within the FAST Instructional System. These include the following:

1) Student reports including both oral and written composition. Formats for both oral and written reports are provided in the Student Book. Specific reports are required as part of some investigations such as Plant Propagation, Animal Care, Ecology of the Class Study Area, Field Productivity Project, World Food Production, etc.

2) Student Projects are periodically included in the FAST Student Book. These are designed to check student understanding of concepts and mastery of skills by requiring them to apply their knowledge to new situations. Examples of such projects include the Submarine Project, the Weather Balloon Project, the Moving Fluids Project, the Dew Point Project, the Solar Heating Project, the Crystal Growing Project, Productivity Project, etc.

3) Identification of unknowns are included several times in FAST Physical Science. These investigations require students to identify "unknown" substances. In such investigations students must apply knowledge and skills developed in preceding work and as such constitute a form of evaluation.

4) Student notebooks and the Student Record Book constitute the student text. It is extremely important for students to begin on the first day to keep organized notes on observations, hypotheses, summary questions, and vocabulary. The following are suggestions for evaluation of record-keeping skills. Check to see that

   (a) data has been entered in the tables provided in the Student Record Book. These pages should be placed in a binder. Additional pages should be added for class notes and for answering summary questions, thus building a record of both individual and class investigation results.

   (b) the problem under investigation or discussion has been stated. Get students in the habit of writing the objectives of the problem or activity being worked on before they do anything else. Put the objective on the board or on a chart so that it can serve as a constant reminder for students.

   (c) there is evidence that the data tables are understood by the student. If Student Record Books are not used, tables should be prepared before beginning laboratory work. Students should understand that they may need to make additional notes of unusual observations or new hypotheses as they investigate.

   (d) a vocabulary list has been kept and added to as new words and concepts are introduced. A class vocabulary list that is posted for reference is also helpful. New words are listed in the Digest of each investigation in the Teacher's Guide.

   (e) students have reviewed their notes to make corrections and additions. It should be made amply clear that record keeping is a scientific skill like reading a balance. Note keeping should not be emphasized to the point of frustration, however.

   (f) students have their notebooks complete. A checklist that can be added to student notebooks at the beginning of the year is helpful and will provide consistent guidelines for completing work. A suggested form is shown in Figure 8. This form may be modified to accommodate specific needs or requirements.

	Date Checked								
1. Investigations are in order.									
2. Investigations are complete.									
3. Graphs and data tables are properly labeled.									
4. Graphs and data sheets are readable.									
5. Notes are complete for problem statements.									
observations.									
class discussion.									
summary questions.									
anomalies.									
vocabulary.									
6. Errors have been corrected.									
7. Conclusions and hypotheses have been revised to reflect class discussion.									
8.									

Figure 8 Student notebook checksheet.

2. FAST Evaluation Instruments

The evaluation instruments in FAST provide a means for objective assessment of the level of mastery of concepts and skills. These evaluations also incorporate the following features.

a. They are designed to be a part of the ongoing instructional experience of the student. They contain some new content which provides an indication of the student's ability to use previously gained knowledge and skills in a new context.

b. They are designed to be followed up by intensive in-class discussion.

c. They may incorporate problems for which there are no fixed "right" answers. (However, there are "wrong" responses--"wrong" in the sense that they are neither appropriate nor adequate to answer the question posed.)

d. They recognize that words may have connotations that could lead students into making what appear to be incorrect responses. In the review of the evaluation results, students should be encouraged to defend the logic of their responses in the light of their interpretation of the problem. Such defense provides teachers with further insights into the development of the students in their capacity for analysis and interpretation.

The evaluation instruments are included in a later section of this Evaluation Guide along with suggestions for their administration and assessment.

3. Class Progress Record

Each evaluation instrument is keyed to a Class Progress Record. This record is an integral part of the evaluation. It is a checklist that shows when students are able to demonstrate mastery of each skill and concept.

Those concepts and skills not shown to be mastered in the administration of the formal evaluation should become the focus of remediation. The student should be constantly encouraged to present evidence of mastery until all entries on the inventory are checked off as mastered. The time of the checkoff of items on the Class Progress Record is not important. The objective is to achieve mastery.

The Class Progress Record shown in Figure 9 is constructed so that a list of students (or a student identification code) appears in the spaces at the left side of the form. When a student masters the concept or skill listed at the top, a check is placed in the appropriate space. The numbers at the very top relate to the specific item on the test instrument which tested the concept. For example, "measures area to the nearest .1 cm" is found in test item 2 of Physical Science Evaluation 1.

STUDENTS	TOTAL	LAB PROBLEMS	Measures distance to nearest .1 cm 1	Measures distance to nearest .02 cm 1	Measures area to nearest .1 cm² 2	Measures mass to nearest .1 g 3	Measures mass to nearest .02 g 3	Measures liquid volume to nearest 1 ml 4	Calculates volume to nearest cm 4	Calculates density (from experimental data) 5	Determines relative density (liquids) 6	DESK PROBLEMS	Selects appropriate graph scale A	Properly labels graph A	Can properly plot graph A	Can read plotted graph point B1	Can interpolate from graph point B2, B3	Can extrapolate from graph point B4	Can determine density graphically B5	Can calculate necessary ballast (floating) C1	Can calculate necessary ballast (subsurface floating) C2	Can calculate necessary ballast (sinking to bottom) C3	Can use proper units

4. Student Progress Record

The Student Progress Record is designed to serve (a) as a statement of self-evaluation by the student, (b) as a joint student-teacher evaluation, (c) as a teacher record of evaluation for the school, and (d) as a report to parents. An example of the Student Progress is shown in Figure 10.

a. As the student's personal evaluation statement, the Student Progress Record allows the student to periodically make a self-evaluation of progress. Such a report is important in that it causes the student to periodically answer the question "What do I think I know?" To the teacher it conveys evidence of the student's capacity to make personal evaluation of accomplishment and gives insight into the student's own sense of progress.

b. As a teacher-student evaluation statement, the Student Progress Record develops the student's self-evaluation skills since it allows the teacher to verify or challenge the student assessment. If the report is a common one, made out by both teacher and student, it serves to supply corrective feedback to the student.

c. As a permanent school record, a copy of the Student Progress Record has several advantages: (1) the Student Progress Record provides specific information on competencies, and (2) its precision will assist in better placement in later coursework and give the next teacher a quick identification of where study in a next course might best begin.

d. As a school report for the parents, the Student Progress Record gives a picture of what students are studying and how well they are doing.

It is recognized that the Student Progress Record may not be accepted as a usable report form to parents. When this occurs, translation into the reporting system of the school will be necessary. Students should be made aware of how such translation is made.

Mechanically, the Student Progress Record can be used in several ways. It is designed to be reproduced and used as a record of student accomplishments. Reporting mastery can be done by (1) having both teacher and student initial a completed skill or concept as it is mastered, (2) having the student check off the skill or concept as the student feels it has been mastered, (3) having the student check off the skill or concept only after it has been verified as mastered by the teacher, or (4) having both teacher and student sign the form after having completed a unit, section, etc., as a means of agreement on the assessment. It may be necessary to use a modified version of the Student Progress Record to satisfy specific needs. It is always helpful to have space available for comments on oral and/or written work.

In the ideal situation, FAST students carry the responsibility for recording their own level of mastery of each skill or concept. Levels of mastery may

SKILLS

1. Can estimate linear distance using appropriate metric units . . . . . .
2. Can estimate area using appropriate metric units . . . . . .
3. Can estimate volume using appropriate metric units . . . . . .
4. Can estimate mass using appropriate metric units . . . . . .
5. Can measure linear distance using appropriate metric units .
6. Can measure area using appropriate metric units . . . . . .
7. Can measure volume using appropriate metric units . . . . . .
8. Can measure mass using appropriate metric units . . . . . .
9. Can measure temperature accurately . . . . . .
10. Can design an experiment with appropriate controls and standards . . . . . .
11. Can make pertinent observations in laboratory and field work . . . . . .
12. Can identify, organize, and record data . . . . . .
13. Can interpret and use data . . . . . .
14. Can make appropriate graphs . . . . . .
15. Can read and interpret graphs . . . . . .
16. Can make clear, concise reports of laboratory and field work . . . . . .
17. Participates in scientific discussion . . . . . .
18. Practices laboratory safety and proper care of laboratory equipment . . . . . .

CONCEPTS IN PHYSICAL SCIENCE

Unit 1 Introduction to the Properties of Matter

1. Can identify and explain the factors contributing to buoyancy . . . . . .
2. Can explain the effects of temperature changes on buoyancy .
3. Can generalize about compression and attenuation of fluids .
4. Can explain the operation of the barometer . . . . . .
5. Can determine the density of solids, liquids, and gases . . .

Unit 2 Changes of State in Matter

1. Can describe the change of state of substances . . . . . .
2. Can distinguish between mixtures and pure substances by physical properties . . . . . .
3. Can measure vapor pressure . . . . . .
4. Can explain vapor pressure, dew point, and humidity . . . . .

Unit 3 Temperature and Heat

1. Can distinguish between temperature and heat . . . . . .
2. Can calculate heat in calories . . . . . .
3. Can identify substances by specific heat . . . . . .

Figure 10 FAST 1 student progress record.

CONCEPTS IN ECOLOGY

Unit 1 Plant Growth

1. Can describe germination and plant growth . . . . . .
2. Can explain the effects of scarification on seeds . . . . . .
3. Can establish new plant growth by at least one propagation method . . . . . .
4. Can identify and explain the components of a valid experimental design . . . . . .

Unit 2 The Physical Environment

1. Can determine and identify properties of soil . . . . . .
2. Can distinguish and explain absorption, percolation, capillarity, and evaporation . . . . . .
3. Can measure and/or calculate relative humidity . . . . . .
4. Can set up a weather station and monitor some aspects of local weather patterns . . . . . .
5. Can prepare and interpret a weather map . . . . . .
6. Can describe factors affecting local climate . . . . . .
7. Can explain and measure transpiration . . . . . .
8. Can trace the water cycle . . . . . .

Unit 3 Animal Care

1. Can care for and raise an animal for six weeks or one life cycle . . . . . .
2. Can describe normal animal growth . . . . . .
3. Can identify animal niches and habitats . . . . . .

Unit 4 Field Ecology

1. Can prepare and interpret a field map . . . . . .
2. Can use appropriate techniques to sample populations in the field . . . . . .
3. Can plan and execute an ecological study in the field . . . .
4. Can identify factors affecting ecological systems . . . . . .

CONCEPTS IN RELATIONAL STUDY

Water Resource Management

1. Can identify major users of water in the community . . . . .
2. Can describe the community water distribution system . . . .
3. Can describe the waste water system of the community . . . .
4. Can identify controversial issues on water use in the community . . . . . .
5. Can identify political, economic, ecological and aesthetic factors affecting decisions on water use in the community . .

Air Pollution

1. Can identify evidence of air pollution in the community . . .
2. Can identify the properties of the major air pollutants . . .
3. Can describe the sources of air pollution in the community .
4. Can identify and explain interrelationships between air pollution and the physical environment . . . . . .
5. Can describe current developments in air pollution control legislation and technology . . . . . .
6. Can describe a citizen's role in controlling air pollution .
7. Can describe some ways the sciences are interrelated . . . .
8. Can identify interrelationships between science and society .

Additional Notes:

Teacher's Signature

be reported in various ways. Some examples are given below.

Sample Directions: "For each skill or concept, write in the space provided the number below which most closely describes your performance." Some examples are given below.

Example 1

1. Some of the time
2. Most of the time
3. All of the time

NA Concept or skill not yet introduced

Example 2

1. Starting
2. Usually successful
3. Proficient

NA Skill or concept not yet introduced

Example 3

S. Satisfactory
I. Improvement needed

NA Skill or concept not yet introduced

These are but a few of the ways of using the Student Progress Record. Modifications may be necessary to fit particular teacher, class, or school needs; however, both the Class Progress Record and the Student Progress Record are an integral part of the FAST program and should be used in the evaluation of student progress.

SUMMARY

This section of the Evaluation Guide described the basic structure of the FAST Instructional System and the explicit Evaluation System. It is assumed that in identifying elements of these systems, teachers will be better able to evaluate the adequacy of their daily interaction with students. The remainder of this guide contains the evaluation instruments designed for use in the FAST program.

FAST 1 EVALUATION INSTRUMENTS

The following pages provide evaluation instruments for FAST 1 Physical Science and Ecology. Also included are suggestions for preparing, organizing, and assessing each evaluation.

	Page
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PHYSICAL SCIENCE	
Evaluation 1, to follow Unit 1, Section A	27
Evaluation 2, to follow Unit 1, Section C	37
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Evaluation 4, to follow Unit 3	64
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ECOLOGY	
Evaluation 1, to follow Unit 1, Section A	76
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FAST 1 CONCEPT INVENTORY[1]

The FAST 1 Concept Inventory is an evaluation instrument designed to involve students in their own self-evaluation as well as to assess their progress in the course. The Concept Inventory consists of a test of concepts considered important in the course. Students respond to each item by indicating what they think to be their general level of understanding on a five-point scale. This sharing of understanding is a powerful aid to the teacher. Clearly a teacher can best aid a student when both know which concepts and skills have and have not been mastered.

The FAST 1 Concept Inventory covers all of FAST 1 and as such could be used as a culminating activity of the course. Additional concepts and/or skills may be added as desired. Selected parts on the inventory can be used anytime throughout the year as a pretest for the year, for a unit, or for an activity. Used in this way the Concept Inventory helps teachers better structure a sequence of activities to meet specific student or class needs. We have used the Concept Inventory over several years with large numbers of students. In all cases student responses were found to be reliable.

---

[1]Young, D. B. and Tamir, P., 1977, Finding out what students know, The Science Teacher, 44(6), pp. 27-28.

FAST 1 CONCEPT INVENTORY

General Instructions

This inventory is designed to find out how well you think you understand concepts in your science course. Each item consists of one or two word concepts that are part of your science course.

This inventory is not a test. There are no right or wrong answers.

Make sure that you understand all the directions before you begin. You may ask questions about any directions you do not understand.

Read each item carefully. Indicate on the Answer Sheet how well you think you understand each concept.

Listed below are concepts in your science program. You may not be familiar with or recognize all concepts. This does not matter.

Indicate on the Answer Sheet to what extent you understand a particular concept.

On the Answer Sheet, mark:

5 - If you think you understand the concept well enough to explain it clearly to someone else.

4 - If you think you understand the concept but not well enough to explain it to someone else.

3 - If you think you have a fair but not good understanding of the concept.

2 - If you are not sure what the concept means.

1 - If you feel that you do not understand the concept at all.

Sample Item

____ 100. animal

Sample Answer Sheet

__4__ 100. animal

The answer marked on the sample answer sheet indicate that the concept "animal" is understood but not well enough to explain it to someone else.

FAST 1 CONCEPT INVENTORY

Answer Sheet

___1. ecology
___2. pollution
___3. matter
___4. germination
___5. properties of matter
___6. propagation
___7. buoyancy
___8. pressure
___9. pollutant
___10. temperature
___11. percolation
___12. fluid
___13. capillarity
___14. compression
___15. evaporation
___16. attenuation
___17. relative humidity
___18. pressure
___19. weather
___20. liquid
___21. transpiration
___22. density
___23. mapping
___24. solid
___25. dispersion
___26. pure substance
___27. water cycle
___28. gas
___29. mixture
___30. life cycle
___31. change of state
___32. sampling
___33. state of matter
___34. scarification
___35. environment
___36. vapor pressure
___37. contour
___38. dew point
___39. climate
___40. heat
___41. calorie
___42. specific heat
___43. measurement
___44. indicator
___45. length
___46. habitat
___47. area
___48. niche
___49. volume
___50. scaling
___51. mass
___52. investigation
___53. population density
___54. experimental control
___55. condensing
___56. experimental standard
___57. population
___58. data analysis
___59. anomaly
___60. experiment
___61. hypothesis
___62. phenomenon
___63. system
___64. relationship
___65. uncertainty in measurement
___66. weight
___67. universal explanation
___68. unit of measurement
___69. technology
___70. vacuum
___71. boiling
___72. graph
___73. solubility
___74. condensation
___75. vapor
___76. physical science
___77. freezing
___78. experimental error
___79. melting
___80. air pressure

PHYSICAL SCIENCE EVALUATION 1

TEACHER'S NOTES

This evaluation has two parts. Part I is designed to be done at the laboratory bench and should take 15-20 minutes to complete. Part II should be done at the student's desk and also requires 15-20 minutes to complete.

PREPARATION

1. General supplies needed:

   a. one copy of evaluation per student
   b. one answer sheet per student
   c. writing equipment

2. Laboratory station supplies needed:

   a. box, square base
   b. metric ruler
   c. cm^2 grid sheet
   d. object marked "ballast," suggest a #6 or #8 rubber stopper
   e. balance
   f. 2 beakers or other containers large enough to use in displacement experiments with the box. Mark one beaker "A" and fill it with saturated Epsom salt solution. Mark the second beaker "B" and fill with water. Add food coloring to the liquids to make them appear different.
   g. graduated cylinder
   h. overflow cup
   i. paper towels

3. Record the following so that student answers may be easily checked.

   a. height of box used at each station
   b. mass of stopper and box at each station
   c. density of liquid used at each station

ADMINISTRATION

1. Grouping: Divide the class into two or three groups. Have one group work at the laboratory bench while others work at their desks. Use one of the systems given below, or devise another method of your own.

   System A: Give each group a fixed time at the laboratory bench.

   System B: Allow students to work until they have finished the laboratory work. When one student has finished, have another take his or her place at the lab station.

2. Laboratory stations: Provide enough laboratory stations so that either system (A) or (B) will operate smoothly.

ASSESSMENT

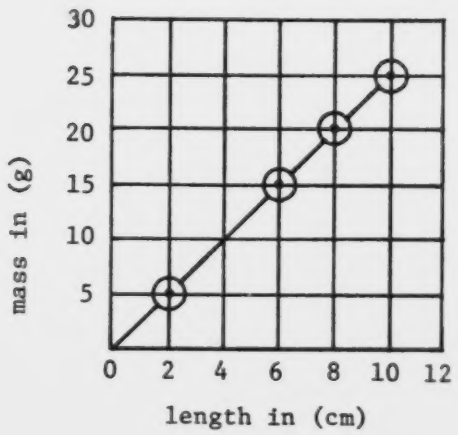
Part I. Laboratory Problems

Problem	Skill or Concept	Discrimination Level
1	Linear measure	a. Knows what method to use b. Can measure to nearest cm c. Can measure to nearest .2 cm
2	Surface measure	a. Knows what method to use b. Can determine to nearest cm^2 c. Can determine to nearest .1 cm^2
3	Mass measure	a. Knows what method to use b. Can measure mass to nearest g c. Can measure mass to nearest .1 g d. Can measure mass to nearest .02 g
4	Volume displaced calculation	a. Knows what method to use b. Can measure displaced volume to nearest cm^3 c. Can measure displaced volume to nearest ml
5	Density calculation	a. Knows a method to use b. Can calculate density to nearest g/cm^3 c. Can calculate density to nearest g/ml
6	Density comparison	a. Knows a method to use b. Can identify denser liquid using box flotation level c. Can identify the most dense liquid using direct density comparisons

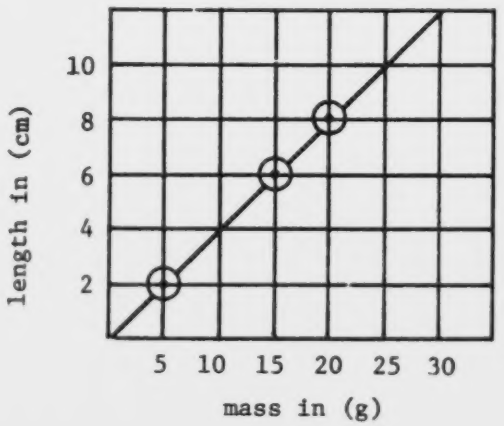
Part II. Desk Problems

Part II. A. Student graphs of the data provided may look like one of the following:

Mass and Length of Gold Wire



Mass and Length of Gold Wire



Skill or Concept	Discrimination Level or Element
Linear graph construction	a. Can select an appropriate title b. Can appropriately label axes c. Indicates units used for each axis d. Can select an appropriate scale for axis e. Can locate proper intersect points f. Can draw appropriate curve

Part II. B.

Problem	Answer	Skill or Concept	Discrimination Level or Element
1	6 g	Direct reading of graph	a. Can read graph directly b. Can use units properly
2	9, 10, or 10.5 g	Interpolate from graph	a. Can interpolate with visual approximation b. Can interpolate with mathematical understanding c. Can use units properly
3	6 ml	Direct reading from graph	a. Can read graph directly using alternate axis b. Can use units properly
4	12 ml	Extrapolate from graph	a. Can extrapolate with visual approximation b. Can extrapolate with mathematical understanding c. Can use units properly
5	1.5 g/ml	Can interpret graph data	a. Can visually approximate interpretation b. Can mathematically approximate interpretation

Part II. C.

Problem	Answer	Skill or Concept	Discrimination Level or Element
1	Add no ballast or any quantity greater than zero and less than 3 g	Object floats on surface when the density is less than the density of the supporting liquid	a. Can identify a method to achieve surface floating b. Evidences understanding of the relationship between density of liquid and density of jar in surface floating
2	Add 3 g of ballast	Object subsurface floats when the density equals that of the supporting liquid	a. Can identify a method to achieve subsurface floating b. Evidences understanding of quantitative relationship between density of liquid and density of jar in subsurface floating
3	Add any amount of ballast over 3 g	Objects sink to the bottom when their density is greater than the density of the supporting liquid	a. Can identify a method to achieve subsurface floating b. Evidences understanding of quantitative relationship between the density of liquid and the density of jar on sinking to the bottom
4	Add 15 g of ballast	Generalized concept: Objects subsurface float when their density is equal to the density of the liquid	a. Can identify a method to achieve subsurface floating b. Evidences understanding of quantitative relationship between density of liquid and density of jar in subsurface floating

CLASS PROGRESS RECORD

Physical Science Evaluation 1

STUDENTS	TOTAL		LAB PROBLEMS														DESK PROBLEMS												
			Measures distance to nearest .1 cm 1	Measures distance to nearest .02 cm 1	Measures area to nearest .1 cm^2 2	Measures mass to nearest .1 g 3	Measures mass to nearest .02 g 3	Measures liquid volume to nearest 1 ml 4	Calculates volume to nearest cm 4	Calculates density (from experimental data) 5	Determines relative density (liquids) 6		Selects appropriate graph scale A	Properly labels graph A	Can properly plot graph A	Can read plotted graph point B1	Can interpolate from graph point B2, B3	Can extrapolate from graph point B4	Can determine density graphically B5	Can calculate necessary ballast (floating) C1	Can calculate necessary ballast (subsurface floating) C2	Can calculate necessary ballast (sinking to bottom) C3	Can use proper units					

PHYSICAL SCIENCE EVALUATION 1

The following exercise will provide an inventory of some of the skills and concepts you have gained so far. It is divided into two parts, laboratory and desk problems.

Your teacher will instruct you about changing from laboratory to desk problems.

Write on the ANSWER SHEET ONLY.

Part I. Laboratory Problems

Be sure that your answers include the unit of measure (cm, cm^3, ml, g, etc.).

1. What is the height of the box?

2. What is the area of the base of the box?

3. What is the mass of the box and ballast? (Be sure the box is dry.) Ballast is material used to add mass to the box.

4. What volume of liquid is displaced by the box in the following situation? Float the box on the liquid in the beaker "A." Then put the ballast into the box. Determine the amount of liquid displaced.

5. What is the density of liquid in beaker "A"?

6. Which is denser, the liquid in beaker "A" or the liquid in beaker "B"? What is your evidence?

Part II. Desk Problems

Part II. A. Graph the following data. Properly label and title the graph.

Table 1 Mass of Various Lengths of Gold Wire

Length (cm)	Mass (g)
2	5
6	15
8	20
10	25

Part II. B. A box was placed in liquid "X." A record was kept of the volume of the liquid displaced and the mass of the box and contents displacing that liquid. The graph of the data is shown in Figure 1. Use this graph in answering the following questions.

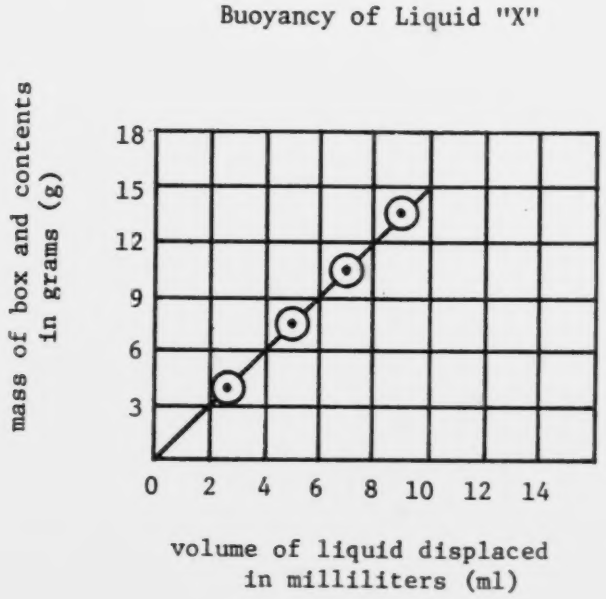


Figure 1 Graph for part II. B., questions 1-5.

1. What would be the mass of box and contents that would displace 4 ml of liquid "X"?

2. What was the mass of the box and contents that displaced 7 ml of liquid "X"?

3. What would be the volume of liquid displaced if the mass of the box and contents were 9 g?

4. Assume the box is large enough. What would be the volume of liquid displaced if the mass of the box and contents were 18 g?

5. What is the density of liquid "X"?

Part II. C. The jar and cap shown in Figure 2 have a total mass of 9 g and a volume of 12 cm^3. The cap can be removed and contents can be added.

Mass of jar (with cap) = 9 g

Volume of jar = 12 cm^3 = 12 ml

Density of water = 1 g/ml

Figure 2 Apparatus used in part II. C.

1. What would you do to get the jar to <u>float</u> on the surface of water?
2. What would you do to get the jar to <u>subsurface</u> float in water?
3. What would you do to get the jar to <u>sink to the bottom</u> in water?
4. What would you do to get the jar to <u>subsurface</u> float in liquid whose density is 2 g/ml?

PHYSICAL SCIENCE EVALUATION 1

ANSWER SHEET

Name _____

Period _____ Date _____

Lab Station I _____

Part I. Lab Problems

Calculations

1. _____ Height
2. _____ Surface Area
3. _____ Mass
4. _____ Volume
5. _____ Density
6. _____ Density Comparison

Evidence _____

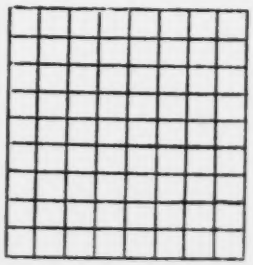
_____

_____

_____

Part II. Desk Problems

Part II. A.



Part II. B.

1. _____
2. _____
3. _____
4. _____
5. _____

Part II. C.

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

4. _____

_____

_____

PHYSICAL SCIENCE EVALUATION 2

TEACHER'S NOTES

This evaluation has two parts. Part I is designed to be done at the laboratory bench and should take 15-20 minutes. Part II should be done at the student's desk and also requires 15-20 minutes.

PREPARATION

1. General supplies needed:

   a. one copy of the evaluation per student
   b. one answer sheet per student
   c. writing equipment

2. Laboratory stations supplies needed:

   Station 1

   a. one glass vial
   b. one 25 ml graduated cylinder half filled with water
   c. one pair chopsticks
   d. an empty 50 ml beaker
   e. paper towels

   Station 2

   a. one test tube with stoppers and glass tube (See diagram on student evaluation page.)
   b. one syringe with tubing adapted to snugly fit glass tubing in stopper
   c. a heat source
   d. one test tube clamp
   e. one 100 ml beaker half filled with water
   f. paper towels
   g. matches or other lighter

Special Note: You will possibly want to post the density of water on the board.

ADMINISTRATION

1. Grouping: Divide the class into two or three groups. Have one group work at the laboratory bench while others work at their desks. Use one of the systems given below, or devise another method of your own.

   System A: Give each group a fixed time at the laboratory bench and at their desk. This is possibly best where the class must be divided into three groups. Allow 10-15 minutes at lab bench.

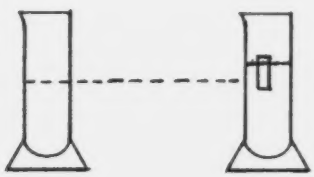
System B: Allow students at the laboratory bench to work until they have finished. When one student has completed his work, another takes his or her place.

2. Laboratory Stations: Provide enough laboratory stations so that the selected system, A or B, will work. Equip all stations as outlined under laboratory station supplies.

ASSESSMENT

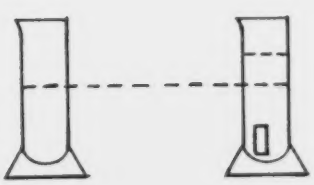
Part I. Laboratory Problems

Station 1: a, b mass of vial



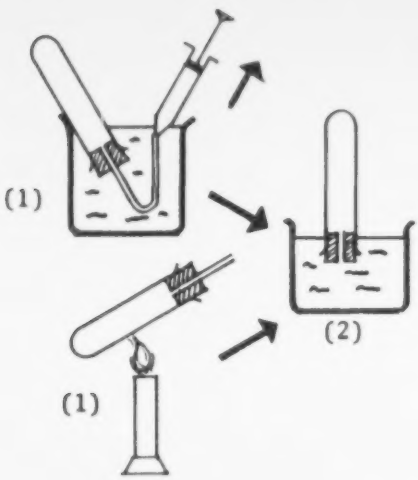
1. Measure the original level of the liquid without the vial.
2. Measure the level of the liquid with vial floating in water.
3. Find the volume of the liquid displaced. (Step 2-Step 1)
4. Multiply the volume displaced by the density of the liquid (1 g/ml for water).

c, d volume of vial



1. Measure the original level of the liquid without the vial.
2. Measure the level of the liquid with vial sunk.
3. Find the volume of the liquid displaced. (Step 2-Step 1)
4. Volume of the liquid displaced equals the volume of the vial.

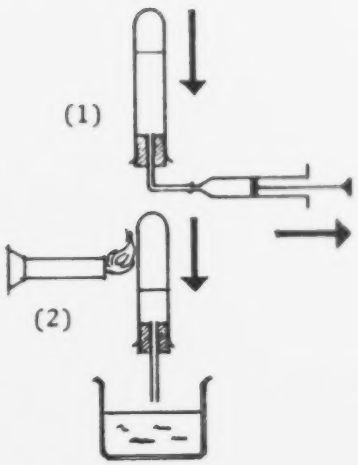
Station 2: a, b fill test tube



1. Evacuate the tube.
2. Remove the syringe and the water will enter.

1. Heat and attenuate air.
2. Put in the water and the water will enter.

c, d remove water

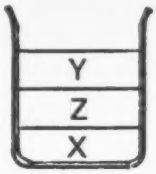


1. Pressure of the gas in the test tube pushes the water into the syringe.
2. Heat applied to the test tube expands the air pushing the water out.

Part II. Desk Problems

1. Density of the vial = 2-5 g/ml (approximately). Soft glass has a density of between 2.4 and 2.8 g/ml, flint glass 2.9-5.1 g/ml. It will be advisable to check density before reading evaluation.

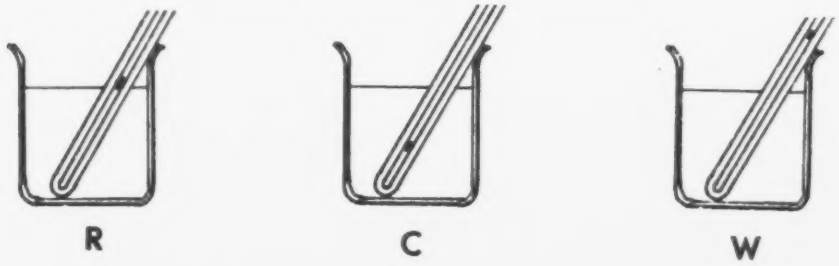
2. Identify the layers with a letter.



3. Explain your prediction in Problem 2.

- X is the most dense. It shows the greatest buoyancy property, therefore it is found on the bottom.
- Z is of intermediate density. Z shows intermediate buoyancy properties.
- Y is the least dense liquid. An object sinks in Y, therefore it is found on the top since it has the least buoyancy property.

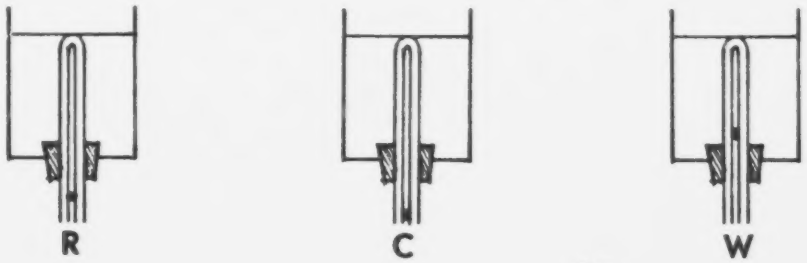
4.



5. Explain your prediction in Problem 4.

- Cold water will reduce the volume of gas. Room temperature water will have about the original volume. Hot water will expand the gas.

6.



7. Explain your prediction in Problem 6.

- Cold (C) water reduces the volume of gas. Room temperature (R) water will have a little more than original volume. Hot (H) water will expand the volume. Gravity will slightly expand the volume.

8.

(✓)

9. Explain your prediction in Problem 8.

- When external pressure decreases, the volume of the trapped gas increases.

10. _____ a. _____ d.

_✓_ b. _✓_ e.

_____ c. _____ f.

CLASS PROGRESS RECORD

Physical Science Evaluation 2

STUDENTS	TOTAL	LAB PROBLEMS	Can find mass of floating object by calculating mass of displaced liquids 1a	Can explain 1a 1b	Can determine an object's volume by measuring the volume of liquid displaced by an object when sunken 1c	Can explain 1c 1d	Can fill a test tube with liquid by removing gas 2a	Can explain 2 2b	Can remove liquid from test tube using differences in gas pressure 2c	Can explain 2c 2d	DESK PROBLEMS	Can calculate density 1	Can identify relative buoyancy of liquids 2	Can explain 2 3	Can relate expansion of gas to changes in temperature 4	Can explain 4 5	Can relate the relative effect of gravity on expansion of gas when temperature changes 6	Can explain 6 7	Can relate volume change of gas to changes in barometric pressure 8	Can explain 8 9	Understands that colder water tends to sink in room temperature water 10a	Understands that hotter water tends to float in room temperature water 10b	Understands that hotter water will tend to rise to the surface of room temperature water 10c	Understands that movement of liquids can be associated with location of hot and cold bodies 10d	Understands that room temperature water sinks in hot water 10a	Understands that room temperature water tends to float on cold water 10f

PHYSICAL SCIENCE EVALUATION 2

The following exercise will provide an inventory of some of the skills and concepts you have gained so far. It is divided into two parts: one with laboratory problems, the other with desk problems.

Part I. Laboratory Problems

Be sure that your answer includes the unit of measure (g, ml, cm^3 etc.).

1. Station 1: The liquid is water. Using only the equipment shown, do the following:

   a. Determine the approximate mass of the vial.
   b. Explain how you determined the mass.
   c. Determine the approximate volume of the glass in the vial.
   d. Explain how you determined the volume of the glass.

   Leave the station as you found it.

Figure 1 Equipment at station 1.

2. Station 2: You have before you a test tube with a single-holed rubber stopper, a syringe, a heat source and a beaker of water, and a test tube holder. Use the equipment as you see fit to do the following:

   a. Fill the test tube half full of water without loosening or removing the stopper.
   b. Explain how you filled the test tube half full of water.
   c. Remove all the water from the test tubes without loosening or removing the stopper.
   d. Explain how you removed all of the water.

   Leave the station as you found it.

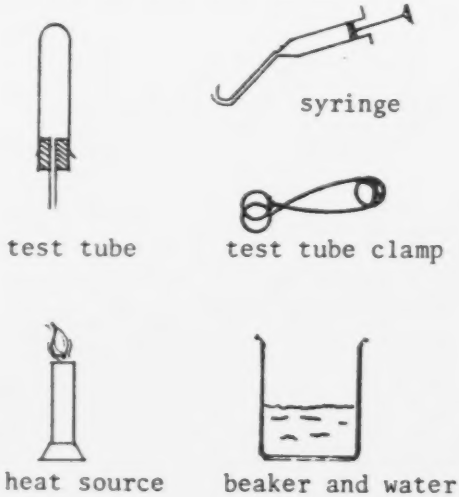
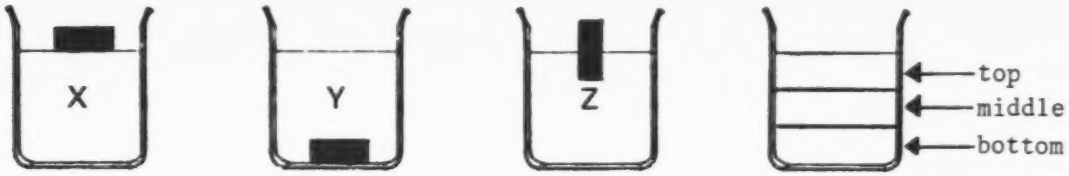


Figure 2 Equipment at station 2.

Part II. Desk Problems

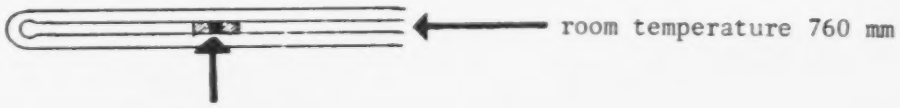
1. What is the approximate density of the glass in the vial used at Station 1?

2. An object is put into three different liquids labeled X, Y, and Z. It floats or sinks as shown in the figures. The three liquids do not mix when poured together, but instead go into three layers. Mark the figure on the Answer Sheet to show which layer you predict will contain liquids X, Y, and Z.

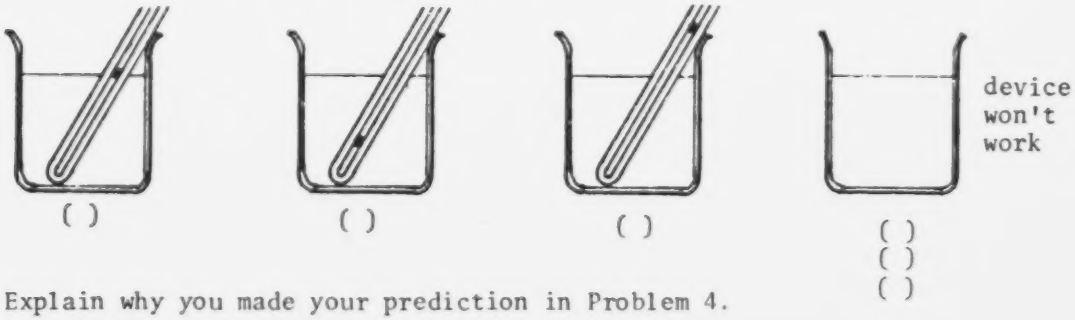


3. Explain why you made your prediction in Problem 2.

4. The device shown below is a capillary glass tube that is open at one end, closed at the other. A small plug of mercury has been put in the center of the column. The tube is to be used as a thermometer.

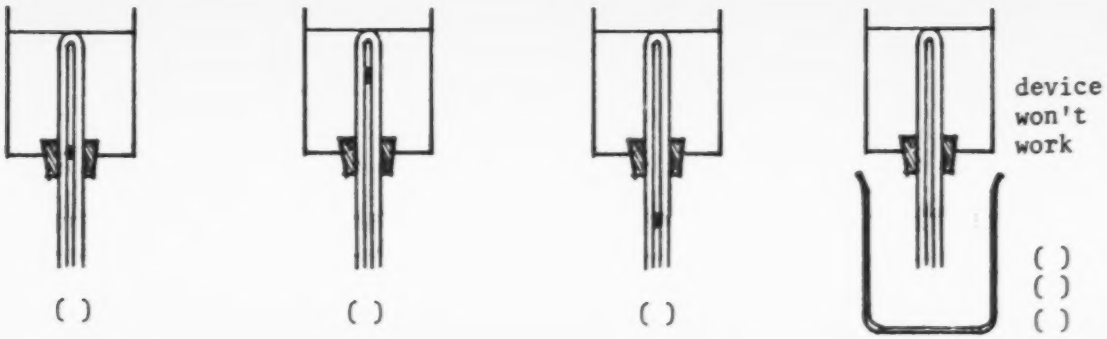


The tube is put in cold water, hot water and room temperature water. Predict which picture would best show the position of the mercury when the tube is put in cold water (C), warm water (W), room temperature water (R). Mark C, W, and R in the space below the corresponding beaker on the Answer Sheet. If the device will not work for one or more of the temperatures mark the appropriate letter below the last beaker.



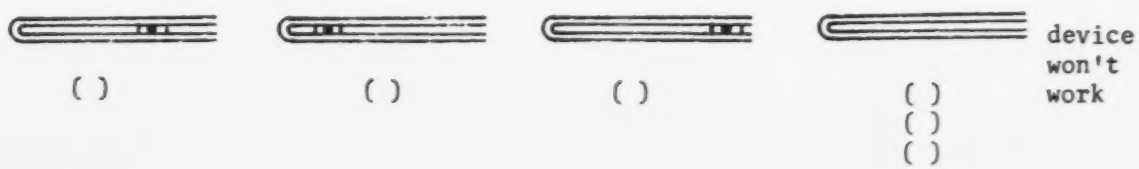
5. Explain why you made your prediction in Problem 4.

6. If the tube used in Problem 4 is turned upside down predict which of the pictures will best show the relative position of the mercury plug when the top of the tube is covered with cold (C), warm (W), and room (R) temperature water. Mark C, W, and R in the space below the corresponding beaker on your Answer Sheet. If the device will not work for one or more of the temperatures mark the space in the last diagram.



7. Explain why you made your predictions in Problem 6.

8. The same tube shown above is to be used as a <u>barometer</u>. Three pressures are measured, 380 mm, 760 mm, and 900 mm. Predict which of the pictures would correspond to the position of the mercury plug at the highest atmospheric pressure. Place a check under the picture.



9. Explain why you made your prediction in Problem 8.

10. Two models to demonstrate the movement of fluids due to difference in temperature are shown in Figures 3 and 4. Check <u>each</u> of the statements that you agree with on your Answer Sheet.

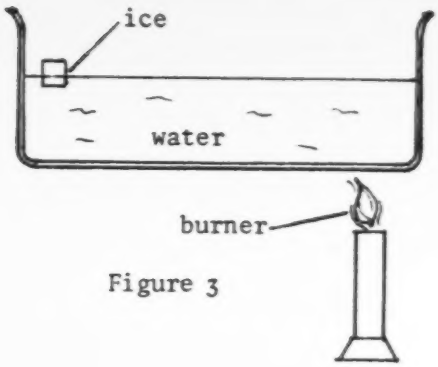


Figure 3

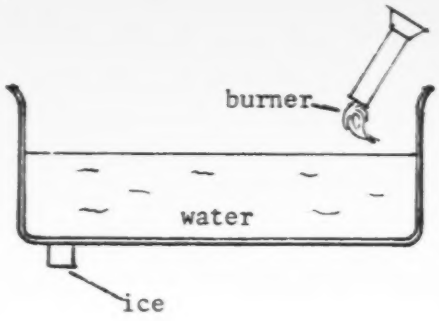


Figure 4

_____a. Ice on the top of the water in Figure 3 will tend to cool only the water near the surface of the container.

_____b. The flame on the surface of the water in Figure 4 tends to heat only the water near the surface.

_____c. The flame under the container in Figure 3 will tend to heat only the water on the bottom.

_____d. Assume after heating Figure 3 we turn off the burners. A balloon filled with room temperature water, similar to that used in the experiment "Balloons in Water," is placed in the hot end. We would predict that the balloon would sink in the hot water.

_____e. Assume the same conditions as set out in statement d. The balloon, however, is placed in the ice end. Again we would predict that the balloon will sink.

_____f. Assume the same conditions as set out in d. The balloon, however, is placed in the ice end of container in Figure 4. Again we would predict that the balloon will sink.

PHYSICAL SCIENCE EVALUATION 2

ANSWER SHEET

Name _____

Period _____ Date _____

Part I. Laboratory Problems

Station 1.

_____ a. Mass of the vial.
b. How did you determine the mass?

_____ c. Volume of the vial.
d. How did you determine the volume?

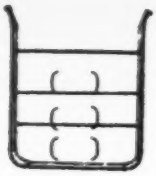
Station 2.

_____ a. Check if you were successful in filling the test tube.
b. How did you fill the test tube?

_____ c. Check if you were successful in removing the water.
d. How did you remove the water?

Part II. Desk Problems

_____ 1. Density of the vial

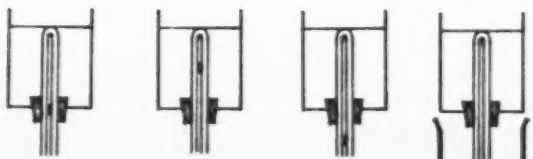
2. 

3. _____
_____
_____

4.

( ) ( ) ( ) ( )
( )
( )

5. _____
_____
_____
_____

6. 

( ) ( ) ( ) ( )
( )
( )

7. _____
_____
_____
_____

8.

( ) ( ) ( ) ( )
( )
( )

9. _____
_____
_____
_____

10. _____ a.
_____ b.
_____ c.
_____ d.
_____ e.
_____ f.

PHYSICAL SCIENCE EVALUATION 3

TEACHER'S NOTES

This evaluation has two parts. Part I is designed to be done at the laboratory bench and should take 15-20 minutes. Part II should be done at the student's desk and also requires 15-20 minutes to complete.

PREPARATION

1. General supplies needed:

   a. one copy of the evaluation per student
   b. one answer sheet per student
   c. writing equipment

2. Laboratory station supplies needed:

   a. ring stand and ring
   b. Erlenmeyer flask, 250 ml, marked as in Figure 1
   c. stopper and tubing as in Figure 1
   d. 2 pinch clamps
   e. plastic catch bucket
   f. syringe, 50 cc
   g. beaker of water, 250-500 ml
   h. paper towels

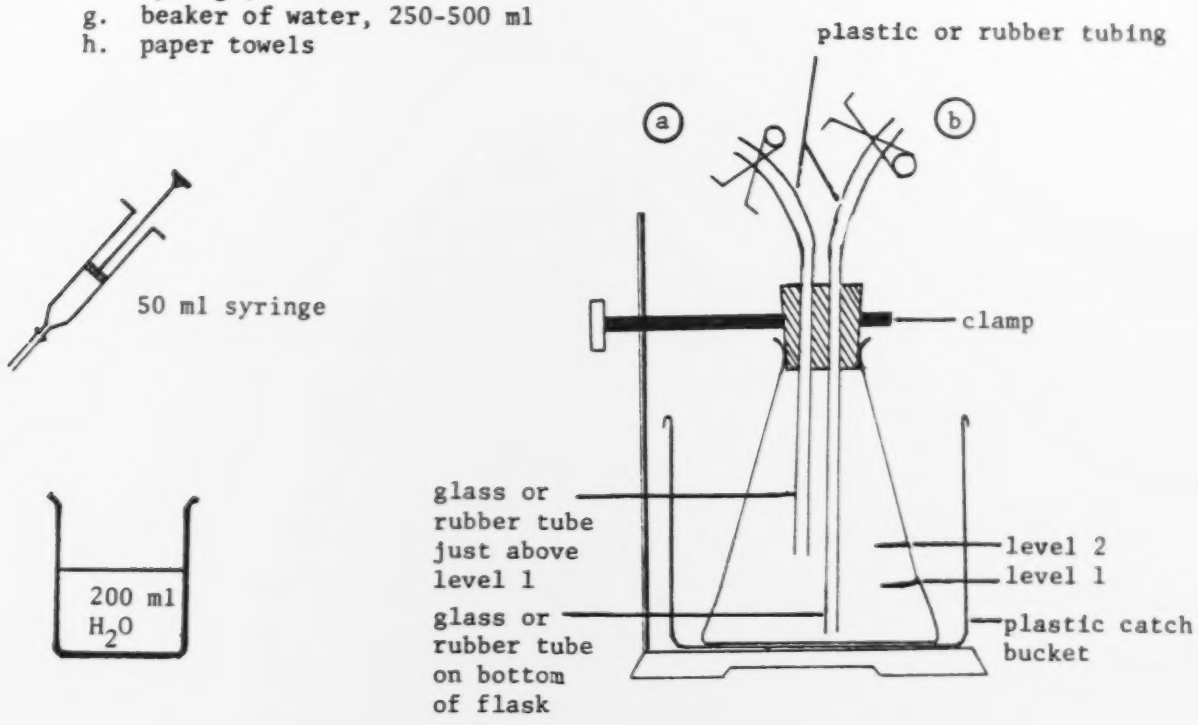


Figure 1 Equipment set up for Evaluation 3.

3. Set up laboratory stations as shown in Figure 1.

4. Test each set up as follows:

   a. Remove both pinch clamps.
   b. Using a syringe, force 50 ml of water into tube (b). Adjust tube (a) so that the water level is right below the open end of the tube. Using a felt pen, mark level 1 on the outside of the flask.
   c. Remove the stopper and add 50 ml more of water. Mark this as level 2 on the outside of the flask.
   d. Empty the flask and reassemble as shown in Figure 1.

5. Special equipment needed:

   a. Have spontaneous fountains available for operation. Students should have access to these while working on desk problems.
   b. Have available for observation, Torricelli's Tube (barometer). The tube may be filled with water.

ADMINISTRATION

1. Grouping: Divide the class into two or three groups. Have one group work at the laboratory bench while others work at their desks. Use one of the systems given below, or devise another method of your own.

   System A: Give each group a fixed time at the laboratory bench and at their desks. This works best in situations where the class must be divided into three groups. Give 15-20 minutes at the lab bench and the remaining time at their desks.

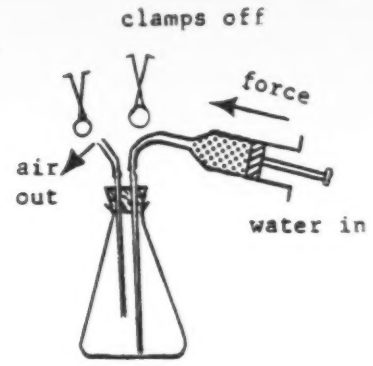
   System B: Allow students at the laboratory bench to work until they have finished. When one student has finished, have another take his or her place.

2. Laboratory stations: Provide enough laboratory stations so that the selected system, A or B, will operate smoothly. Equip all stations as outlined under "laboratory station supplies needed."

ASSESSMENT

Part I. Laboratory Problems

1.

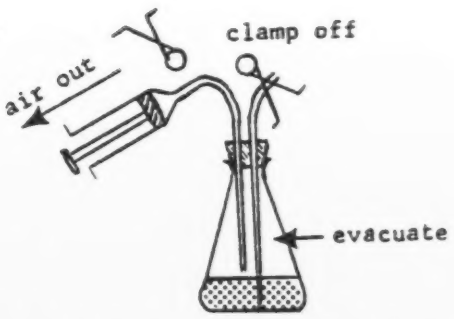


a. Remove clamps.

b. Connect syringe to long tube.

c. Force water into flask.

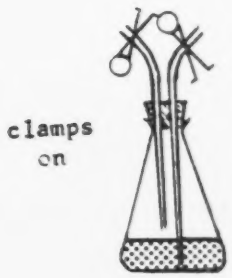
2.



Step 1

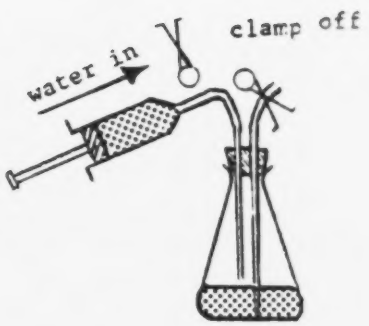
a. Remove clamp on short tube only.

b. Evacuate air.



Step 2

c. Clamp on short tube.



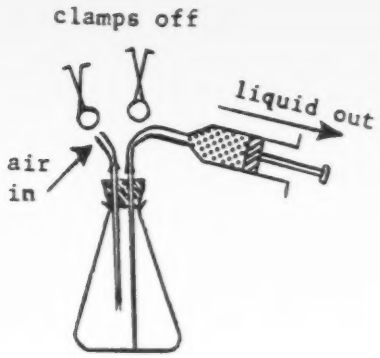
Step 3

d. Attach syringe with water in short tube.

e. Remove clamp from short tube.

f. Water enters flask.

3. Alternative a

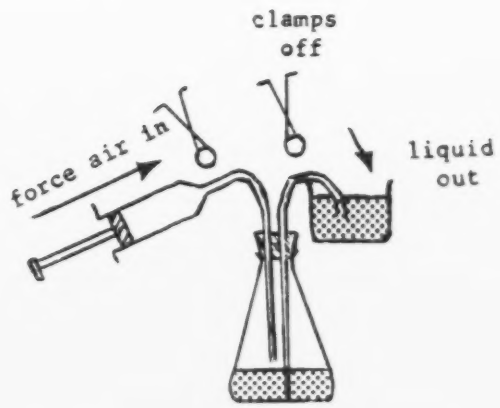


a. Remove clamps

b. Attach syringe to long tube.

c. Remove water by evacuating.

Alternative b



a. Remove clamps.

b. Attach syringe to short tube.

c. Force out water.

Part II. Desk Problems

All of the following desk problems lend themselves to demonstration.

1. ____ a.
____ b.
✓ c.
____ d.

2. Water is liquid. Liquids are seemingly incompressible. Pressure does not seem to compress a liquid.

3. ____ a.
✓ b.
____ c.
____ d.

4. Air is a gas. Gases are compressible. Pressure compresses a gas.

5. ✓ a.
____ b.
____ c.
____ d.

6. Vacuums are nothing. Vacuums occupy no space. The plunger can be pushed down to zero.

7. ✓ a.
____ b.
____ c.
✓ d.
____ e.

8. ____ a.
✓ b.
✓ c.

9. 3 a.
4 b.
5 or 8 c.
6 d.
7 e.

10. --Normally Blank--

There is a one for one similarity. This section may be filled in with a perfectly logical solution so be sure to check it. Answer to c is subtle since the liquid is not in the tube but in the chamber in the barometer.

11. --Normally Blank--

As long as there is no air in the system an evacuating syringe will not work.

The last 3 problems are quite difficult. A real feather in any student's cap who can solve them. They are used here to get an extension of knowledge gained.

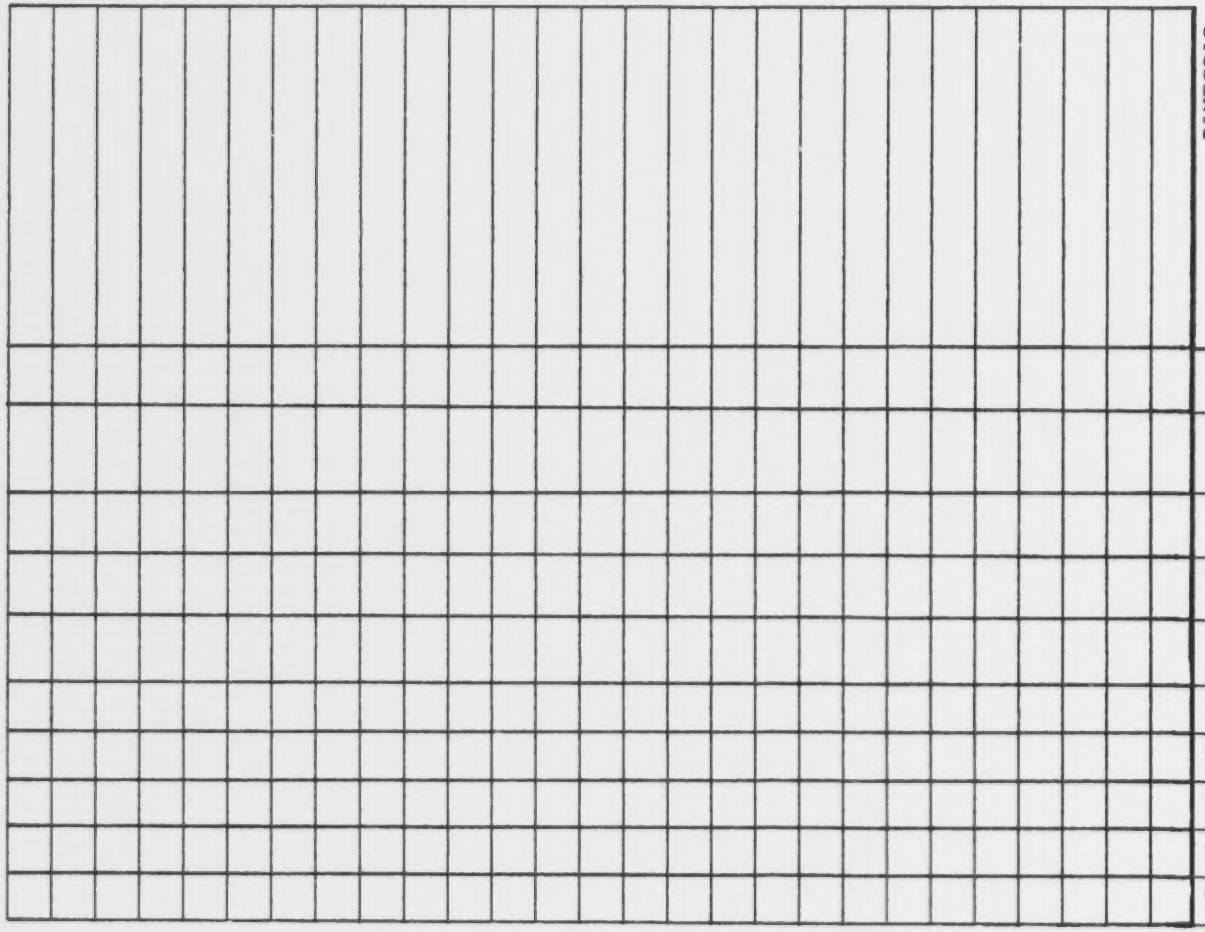
12. This answer should include the fact that there is no gas in the bottle to drive the liquid into the vacuum.

13. Possible ways:
Step 1. a. Heat the liquid. Expansion would force out some liquid.
b. Cool liquid. Air will enter to fill space left by the liquid that has been forced out.
c. Use a syringe.
Step 2. Start with b above using the cooling sequence.
(Any other good ideas, send them in.)

CLASS PROGRESS RECORD

Physical Science Evaluation 3

STUDENTS	TOTAL	LAB PROBLEMS	Can fill container with liquid when gas must be displaced by force or evacuation 1a-b	Can explain 1a-b 1c	Can fill container with liquid when gas must be displaced by evacuation 2a-b	Can explain 2a-b 2c	Can empty container of liquid by increasing pressure 3a-b	Can explain 3a-b 3c	DESK PROBLEMS	Understands that water is not noticeably compressed under pressure 1	Can explain that water is not noticeably compressed under pressure 2	Understands that gases are readily compressed 3	Can explain that gases are readily compressed 4	Understands that vacuums occupy no volume 5	Can explain that vacuums occupy no volume 6	Understands that gas enters empty space spontaneously (without being pushed) 7a	Understands that gases completely occupy the volume in which they are contained 7b	Understands that liquid is pushed out of system by pressure in fountain 7c	Understands that volume occupied by gas increases when container expands 7c



Understands that when some gas leaves a space the quantity of gas remaining is reduced	7d
Understands that if no gas is removed from a container the quantity of gas remains constant even though volume is increased	7e
Understands that liquids are forced into space of low pressure by higher pressure	8a
Understands that the same force will push a less dense liquid higher in an evacuated tube than a more dense liquid	8b
Understands that the height to which a liquid will rise in an evacuated tube depends on the density of the liquid	8c
Understands the general structure of a barometer	9
Understands operation of parts of a barometer	10
Understands that liquids must be forced to be moved into low pressure regions	11
Can explain that liquids must be forced to be moved into low pressure regions	12
Can explain how to employ forces other than air pressure to move liquids	13

PHYSICAL SCIENCE EVALUATION 3

TORRICELLI'S TUBE

The following exercise will provide an inventory of some of the skills and concepts you have gained so far. It is divided into two parts, laboratory problems and desk problems. Your teacher will instruct you about changing from laboratory to desk problems.

Write on the ANSWER SHEET ONLY.

Part I. Laboratory Problems

All of the following problems refer to the apparatus at the laboratory station as shown in Figure 1. The problems are to be solved without moving the flask or removing or loosening the stopper and/or tubes.

1. a. Devise a way to add 50 ml of water to the flask. (Level 1)
   b. Test your method.
   c. Draw a picture of your method and/or explain how it works.

2. a. Devise a way to add another 50 ml or a total of 60 ml of water to the flask. (Level 2)
   b. Test your method.
   c. Draw a picture of your method and/or explain how it works.

3. a. Devise a way to empty the flask.
   b. Test your method.
   c. Draw a picture of your method and/or explain how it works.

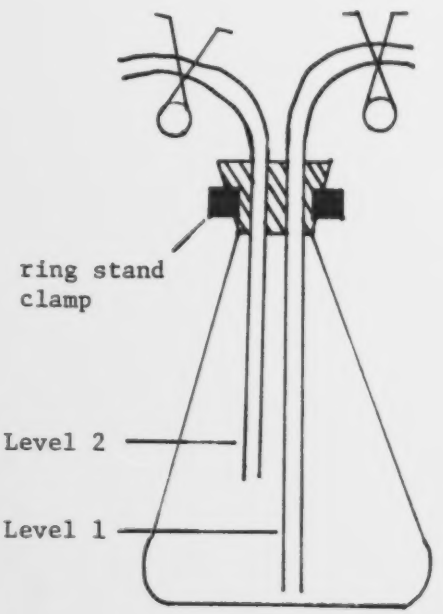


Figure 1 Flask to be filled and emptied at lab bench.

Leave the flask empty at the station.

Part II. Desk Problems

Problems 1, 3, 5--Place a check (✓) on the Answer Sheet in front of each phrase that correctly completes the sentence.
Problems 2, 4, 6--Briefly write an explanation on the answer sheet.

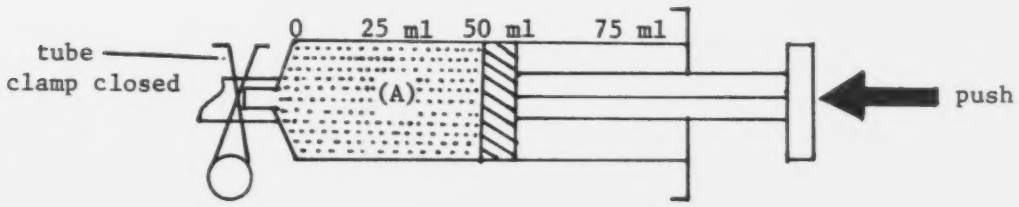


Figure 2 Syringe for problems 1-6.

1. The syringe chamber (A) in Figure 2 is filled with 50 ml of water. The plunger is pushed. The plunger will finally rest at

   a. _____ 0 ml.
   b. _____ between 0 and 50 ml.
   c. _____ 50 ml.
   d. _____ between 50 and 75 ml.

2. Explain why you made your selection in problem 1.

3. The syringe chamber (A) in Figure 2 is filled with 50 ml of air. The plunger is pushed. The plunger will finally rest at

   a. _____ 0 ml.
   b. _____ between 0 and 50 ml.
   c. _____ 50 ml.
   d. _____ between 50 and 75 ml.

4. Explain why you made your selection in problem 3.

5. The syringe chamber (A) in Figure 2 is completely evacuated (made a vacuum). The plunger is pushed. The plunger will finally rest at

   a. _____ 0 ml.
   b. _____ between 0 and 50 ml.
   c. _____ 50 ml.
   d. _____ between 50 and 75 ml.

6. Explain why you made your selection in problem 5.

Problems 7 and 8 refer to the fountain shown in Figure 3. A long tube is attached to the bottle of the fountain. A long glass column is used to enclose the fountain. A 50 ml syringe is used to evacuate the outer glass column. Place a check (✓) on the Answer Sheet in front of all phrases that correctly identifies the problem.

7. The plunger of the evacuating syringe is pulled back to the 50 ml mark. Immediately,

   _____ a. air rushed into the syringe.
   _____ b. the total volume occupied by the air in the outer glass column is less than it was originally.
   _____ c. the total volume occupied by the air still in the fountain is less than it was originally.
   _____ d. there is less air in the outer column than before the plunger was pulled.
   _____ e. there is less air in the fountain than before the plunger was pulled.

8. Water is first put in the fountain. When the plunger of the evacuating syringe is pulled to the 50 ml mark the water rises 26 cm. The system is then changed. An equal volume of mercury is substituted for water. All other conditions are the same as they were when water was present. The plunger of the evacuating syringe is pulled to the 50 ml mark. The density of mercury is 13.6 g/cm^3.

   _____ a. The mercury will not rise in the long tube.
   _____ b. Water will rise higher in the long tube than will mercury.
   _____ c. The height to which mercury will rise depends on its density.

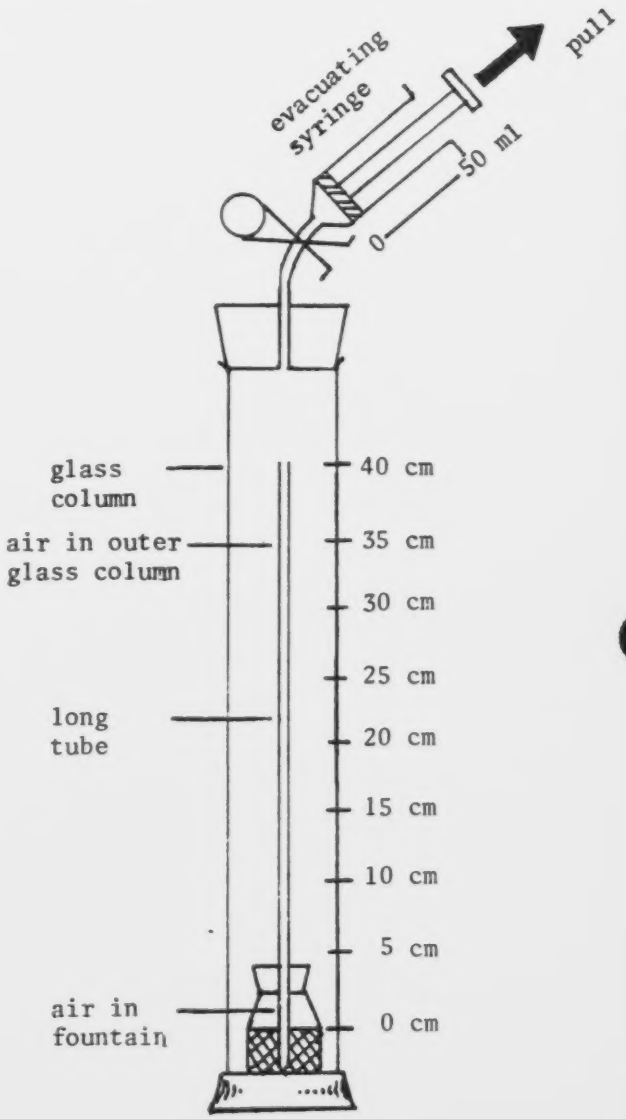


Figure 3 Fountain in long chamber for problems 7 and 8.

Problems 9 and 10--Ima Doubter says that the fountain works like Torricelli's Tube. She claims that each part of the Torricelli's Tube has a similar part in the fountain system. Refer to Figures 4 and 5.

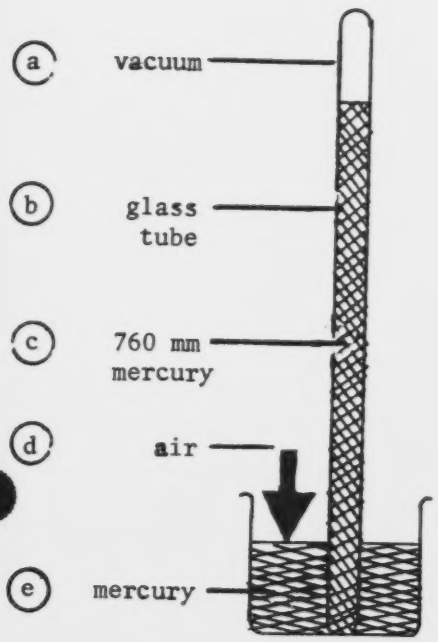


Figure 4 Torricelli's Tube.

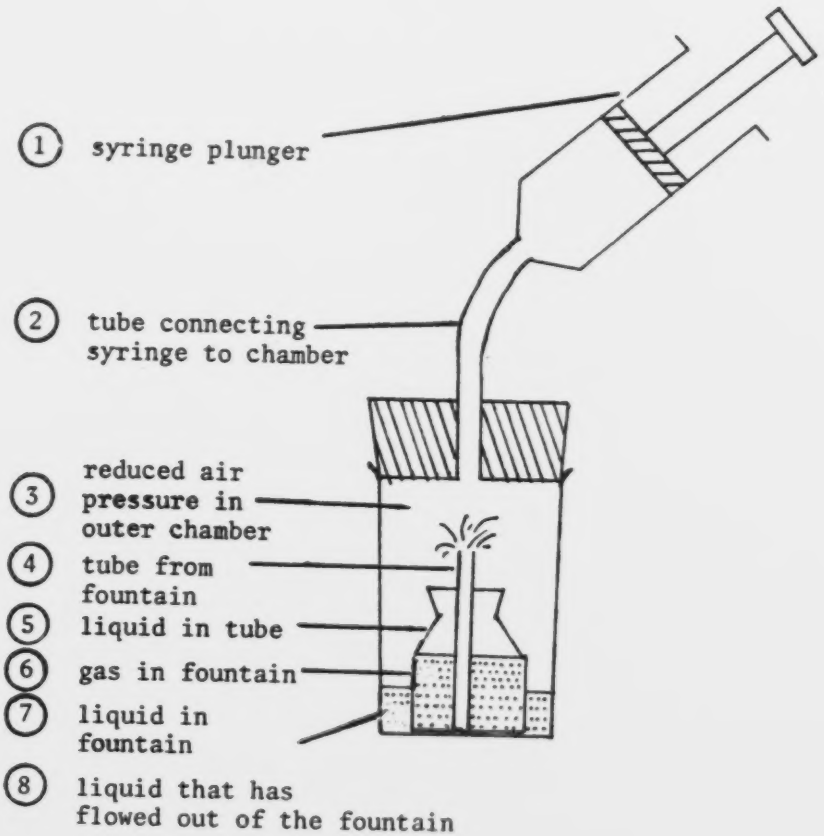


Figure 5 Fountain system to be used in problems 9 and 10.

9. If Ima is right, match the lettered parts of Torricelli's Tube with the corresponding numbers found in the fountain system.

a. _____ c. _____ e. _____

b. _____ d. _____

10. If Ima is not right, explain how the fountain operated differently from Torricelli's Tube. Use the five lettered parts of Torricelli's Tube as reference parts to show the differences from the 7 numbered parts in the fountain system.

Problems 11, 12, and 13--A bottle is completely filled with a dark liquid. A stopper and a tube are inserted as shown in Figure 6. Iva Hunch says that he can remove the liquid with a syringe without taking off the stopper.

11. If you agree, draw a picture of how he could do it and/or explain how it could be done.

12. If you disagree with Iva, explain why you disagree.

13. If you disagree, devise another way that might work to remove the liquid.

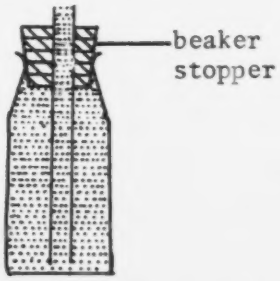


Figure 6 Bottle filled with liquid for problems 11-13.

PHYSICAL SCIENCE EVALUATION 3

ANSWER SHEET

Name _____

Period _____ Date _____

Part I. Laboratory Problems

1. a. _____ Yes. Check "Yes," if you devised a method.
   b. _____ Yes. Check "Yes," if your method succeeded.
   c. Explain your method.

2. a. _____ Yes. Check "Yes," if you devised a method.
   b. _____ Yes. Check "Yes," if your method succeeded.
   Explain your method.

3. a. _____ Yes. Check "Yes," if you devised a method.
   b. _____ Yes. Check "Yes," if your method succeeded.
   c. Explain your method.

Part II. Desk Problems

1. _____ a.
   _____ b.
   _____ c.
   _____ d.

2. _____

3. _____ a.
   _____ b.
   _____ c.
   _____ d.

4. _____

5. _____ a.
   _____ b.
   _____ c.
   _____ d.

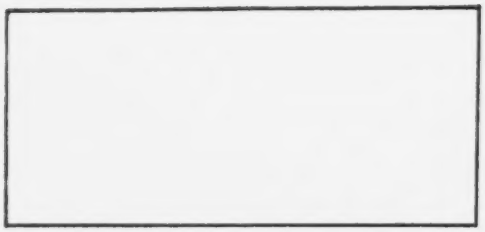
6. _____

7. ____ a.
____ b.
____ c.
____ d.
____ e.

8. ____ a.
____ b.
____ c.

9. ____ a.
____ b.
____ c.
____ d.
____ e.

10. _____

11. 

12. _____

13.

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PHYSICAL SCIENCE EVALUATION 4

TEACHER'S NOTES

This evaluation has two parts. Part I is designed to be done at the laboratory bench and should take 15-20 minutes. Part II should be done at the student's desk and requires 20-30 minutes to complete.

PREPARATION

1. General supplies needed:

   a. one copy of the evaluation per student
   b. one answer sheet per student
   c. writing equipment.

2. Laboratory station supplies needed:

   a. ring stand and ring
   b. 2 beakers 100 ml
   c. wire gauze
   d. balance
   e. thermometer
   f. paper towels
   g. goggles
   h. aprons
   i. tongs
   j. heat source
   k. water
   l. metal or glass object
   m. stone (if comparative approach used)

ADMINISTRATION

1. Grouping: Divide the class into two or three groups. Have one group work at the laboratory bench while others work at their desks. Use one of the systems given below, or devise another method of your own.

   System A: Give each group a fixed time at the laboratory bench and at their desks. This is possibly best where the class must be divided into three groups. Give 10-15 minutes at lab bench; 20-30 minutes at desks.

   System B: Allow students at laboratory bench to work until they have finished. When one student has completed his or her work, another goes to the bench.

2. Laboratory Stations: Provide enough laboratory stations so that the selected system, A or B, will work. Equip all stations as outlined under laboratory station supplies.

Special Notes

Hot Water Source: It may help to have a common container with boiling water so students need not take time to heat water themselves.

Objects: Use any piece of iron, a bolt or large nut, for example. Alternative objects are a glass bottle, broken pottery piece, etc. One object is about all that can be dealt with in 20 minutes.

Student Preparation for Evaluation: Some classes may need to have the problem given the day before the evaluation. This technique is best used for measuring manipulation and mathematical skills.

Use of Notes: It is suggested that students be allowed to use their notes. This will alleviate problems associated with formulas, etc.

Student Questions Concerning "Best": Do not define "best" for students. Students should define "best" in relation to mass, volume, convenience, cost, etc. themselves.

Use of Evaluation: As written, Evaluation 4 is best used with students who have proficiency with mathematical skills. For students without such skills, a comparative approach can be used in which students use both stones and either glass or iron. This will probably take a full period.

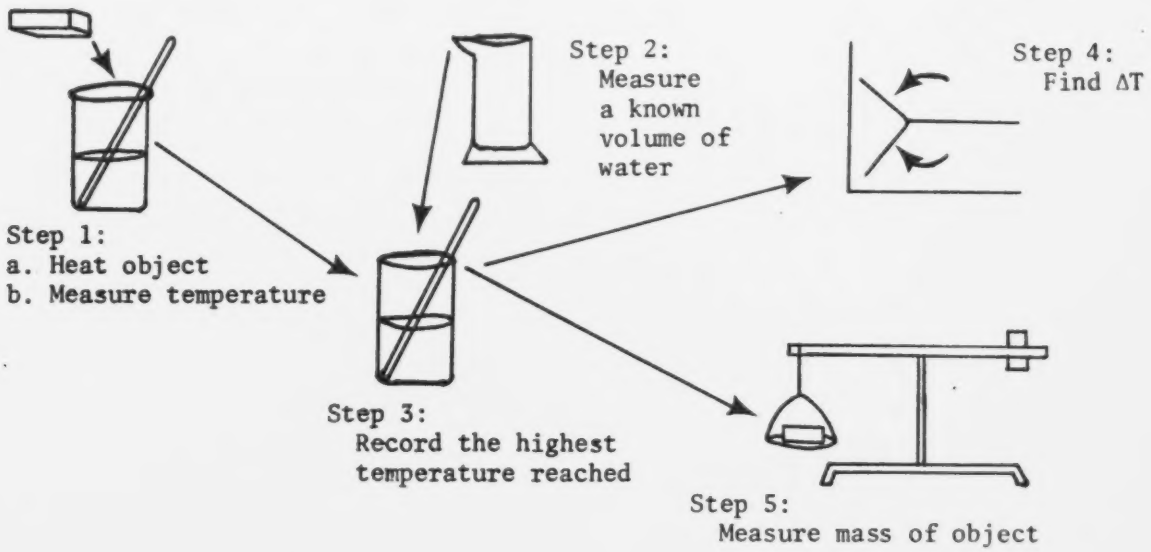
ASSESSMENT

Part I. Laboratory Problems

This is a science and technology problem. Students must do two things: (1) describe what their criteria for "bestness" are (mass, volume, ease or convenience, cost, etc.) and (2) match these with capacity of various objects to transfer heat.

1. Heat transfer measurement

This is a problem in determining the specific heat of an object.



Step 6: Calculation:

$$\frac{\text{Mass}_{H_2O} \times \Delta T_{H_2O} \times \text{cal/g/°C}}{\text{Mass}_{Object} \times \Delta T_{Object}} = \text{sp ht}$$

Some Specific Heats

Substance	Specific Heat (cal/g/°C)	Density (g/cm^3)
Water	1	1
Iron	.1	8
*Glass	.2-.5	5
**Stone	.3-.6	3

*Soft glass has a sp ht of about 0.2 cal/g/°C. Flint glass about 0.5 cal/g/°C.

**Sandstone has a sp ht of about 0.3 cal/g/°C. Igneous stone up to 0.6 cal/g/°C.

2. Some considerations

a. Considering the specific heat: Stones transfer 0.3 calories to 0.6 calories per gram of matter per 1°C change in temperature. Thus, heat transfer per unit of mass of stone is greater than that of glass, which is greater than that of iron.

Stone > Glass > Iron

b. Considering unit of value: Iron is the most compact, but stones still produce more heat transfer per cm^3.

Stone > Glass > Iron

Iron $\frac{.1 \text{ cal}}{g\ ^\circ C} \times \frac{8 \text{ g}}{cm^3} = \frac{.8 \text{ cal}}{^\circ C\ cm^3}$

Glass $\frac{.2 \text{ cal}}{g\ ^\circ C} \times \frac{5 \text{ g}}{cm^3} = \frac{1 \text{ cal}}{^\circ C\ cm^3}$ $\qquad \frac{.3 \text{ cal}}{g\ cm^3} \times \frac{5 \text{ g}}{cm^3} = \frac{1.5 \text{ cal}}{^\circ C\ cm^3}$

Stone $\frac{.3 \text{ cal}}{g\ ^\circ C} \times \frac{6 \text{ g}}{cm^3} = \frac{1.8 \text{ cal}}{^\circ C\ cm^3}$ $\qquad \frac{.6 \text{ cal}}{g\ ^\circ C} \times \frac{6 \text{ g}}{cm^3} = \frac{3.6 \text{ cal}}{^\circ C\ cm^3}$

c. Considering conveniences-cost: Probably this again favors stones, unless one is in the middle of a prairie.

Part II. Desk Problems

1. $\Delta T = [40°C - (-10°C)] = 50°C$

2. Heat to raise temperature of water is 2500 cal.

   $\Delta T = 50°C$

   Mass $H_2O = 50$ g

   sp ht = 1 cal/g/°C

   $\Delta H = \Delta T \times$ sp ht $\times$ Mass

   $= 50°C \times \frac{1 \text{ cal}}{\text{g } °C} \times 50 \text{ g}$

   $= 2500$ cal

3. Heat exchanged in cooling alcohol is 290 cal.

   $\Delta T = (40°C - 50°C) = -10°C$

   sp ht = .58 cal/g/°C

   Mass Alcohol = 50 g

   $\Delta H = \Delta T \times$ sp ht $\times$ Mass

   $= -10°C \times \frac{.58 \text{ cal}}{\text{g } °C} \times 50 \text{ g}$

   $= -290$ cal

4. ___ a. (1) Water will boil from 0°C to 374°C depending on the pressure. Students will probably say, (2) water will boil at temperature above and below 100°C, or water under 760 mm of pressure boils below 100°C. Thus, 100°C is for boiling at standard pressure.

   ✓ b. TRUE. Thermometers are standardized and sealed. Usually the only kind of problem they present involves separation of the mercury column.

   ___ c. Water can be made to boil at 80°C by decreasing the atmospheric pressure. Change of volume has no effect.

   ✓ d. TRUE. Water under increasing pressure can be made to boil up to a temperature of 374°C. Above 374°C water goes into the gas state no matter what the pressure is.

   ___ e. Boiling in an open container takes place at 100°C only when the atmospheric pressure is 760 mm.

   ___ f. When the barometric pressure is below normal, boiling will take place below its normal boiling point. In this case, below 78°C.

CLASS PROGRESS RECORD

Physical Science Evaluation 4

STUDENTS	TOTAL	LAB PROBLEMS	Can design a technique to find the amount of heat transferred from object 1	Can measure heat transfer 1	Can explain 1 2	Can perform mathematical operations to calculate specific heat 2	Can establish a rationale for determining best object for heat transfer 2	DESK PROBLEMS	Can calculate ΔT from experimental data 1	Can calculate ΔT in problem format 1	Can calculate the quantity of heat transferred in problem format by water 2	Can calculate the quantity of heat transferred in problem format by specific heat 3	Understands that water can be made to boil over a range of temperature 4a	Understands that two thermometers can be used to check each other 4b	Understands the volume of water does not affect boiling point 4c	Understands that water can be made to boil over 100°C 4d-e	Understands that low atmospheric pressure lowers boiling point 4f

PHYSICAL SCIENCE EVALUATION 4

The following exercise will provide an inventory of some of the skills and concepts that you have covered in the last unit. It is divided into two parts, one done in the laboratory and the other at your desk. Your teacher will instruct you as to when to begin each part.

Write on the ANSWER SHEET ONLY.

Part I. Laboratory Problems

Many people of the world still heat water in baskets that are woven to be water tight. Heat is provided by hot stones dropped into the water in the basket. Experiment with the object at your station and determine if it will do a better job in transferring heat than stones. Data on heating stones and other substances is shown in Table 1.

Table 1 Properties of Substances

Substances	Boiling Point (°C)	Melting Point (°C)	Density (g/cm^3)	Reaction to Solvents	Specific Heat (cal/g/°C)	Color
Stones	2,800 Decom-poses	1700	6	Insoluable Water Acids Bases	.3	Dark Brown
Glass	---	1100	5	Insoluable Water Acids Base	---	Color-less
Iron	3,000	1535	8	Soluable in acid	---	Silver

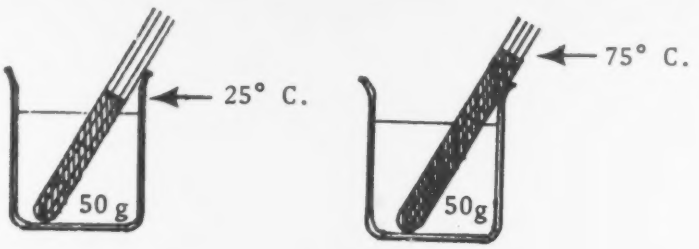
1. **Which transfers heat best, stones or the object at your station?**

2. Explain the reasoning for your answer in the experiment in terms of your experimental evidence. Show all calculations.

Part II. Desk Problems

1. What is the temperature change, ΔT, in raising the temperature of 50 g of alcohol from -10°C to 40°C?

2. How much heat does it take to raise the temperature of 50 g of water from 25°C to 75°C?



3. What is the amount of heat exchanged by cooling 50 g of alcohol from 50°C to 40°C? The specific heat of alcohol is .58 cal/g/°C.

4. Bill Pill suddenly took the thermometer out of a beaker of boiling water and announced to his partner, Ima Doubter, "This thermometer is broken." "Why?" asked Ima. "It reads 98° Celsius when the water boils," replied Bill.

Bill got another thermometer. "This one is broken too," he said in disgust, "it reads 98.2° Celsius in the same boiling water.

"I doubt that it's broken," said Ima.

"I'll try it in alcohol. Ethyl alcohol boils at 78° Celsius," said Bill. After boiling the alcohol and taking the temperature, Bill said, "They are both broken all right, one reads 76.2° and the other reads 76.4°."

The following statements were recorded from the discussion above. Place a check (√) by the statements with which you agree on the Answer Sheet. Correct any statement with which you disagree by rewriting it.

_____ a. The boiling of water takes place only at 100°C. This is why the boiling point of water is listed as 100°C.

_____ b. Usually, when two thermometers are put in water and read the same, or about the same temperature, we can be reasonably sure they are not broken.

_____ c. Water can be made to boil at 80°C by increasing the volume of the water.

_____ d. Water can be made to boil at temperatures above 100° by increasing pressure.

_____ e. Boiling in an open container always takes place at 100°C.

_____ f. When the atmospheric pressure is less than normal, alcohol should boil above 78°C.

PHYSICAL SCIENCE EVALUATION 4

ANSWER SHEET

Name _____

Period ____ Date _____

Part I. Laboratory Problems

____ 1. The best object for transferring heat.

2. Write the explanation of your answer in terms of your experimentations. Show all calculations and measurements.

Part II. Desk Problems

____ 1. ΔT for temperature change.

____ 2. Heat to raise temperature of water.

____ 3. Heat exchanged in cooling alcohol.

4. ____ a. _____

_____

_____

____ b. _____

_____

_____

____ c. _____

_____

_____

____ d. _____

_____

_____

____ e. _____

_____

_____

____ f. _____

_____

_____

OTHER PHYSICAL SCIENCE EVALUATIONS

There are several evaluation tools built into the FAST 1 student materials. These include those investigations developed as "projects" or identification of "unknowns," as well as investigations in which students are required to present oral and/or written reports of their work. The following investigations in physical science are designed to get an indication of student inventiveness.

PS Problem 14. Submarine Project tests students' abilities to apply their knowledge of liquid buoyancy in building a submarine.

PS Problem 17. Weather Balloon Project tests students' abilities to apply their knowledge of density and buoyancy of gases in designing a weather balloon.

PS Problem 22. Identification of Unknowns tests students' abilities to apply their knowledge of the physical properties of pure substances and mixtures to the identification of unknown substances.

PS Problem 28. Moving Fluids Project tests students' abilities to apply their knowledge of buoyancy in designing a model of wind and water currents.

PS Problem 33. Dew Point Project tests students' abilities to apply their knowledge of condensation in making a dew point measuring device.

PS Problem 35. Heat Project tests students' abilities to develop an operational definition of heat and to make a heat measuring device.

PS Problem 40. Specific Heat and the Identification of Unknown Substances tests students' abilities to identify an unknown substance on the basis of its specific heat.

PS Problem 41. Solar Heating Project tests students' abilities to apply concepts of heat and temperature to the design and construction of a solar heating device.

RELATIONAL STUDY EVALUATION

The following problems are designed to get a measure of students ability to apply their knowledge of the ecology and physical science to practical environmental problems.

R Problem 5. Air Pollution and the Physical Environment tests students' ability to relate air pollution data to industrial site development.

R Problem 7. The Future of Air Pollution tests students' ability to project futuristically the solutions of the problem of air pollution.

ECOLOGY EVALUATION 1

TEACHER'S NOTES

This evaluation deals almost exclusively with assessing student comprehension of how to design a valid experiment and how to interpret the results of such an experiment. The teacher may wish to refer to page 141 in the Student Book for basic guideline questions on validity of experimental design and interpretation of results. The main parts to look for in assessing the validity of an experiment are the problem statement, limiting extraneous variables, inclusion of a control, number of replications, and standards that were set.

There are several alternative methods to evaluating students' skills in experimental design. Some of the methods are given below. Look over the suggested ways and choose the method or combination of methods which is appropriate to your class, or design another way of your own.

Alternative Evaluations for Ecology Unit 1

Alternative Order of Difficulty	Materials Needed	Method of Presentation	Description
1 (Simple)	sunflower seeds	oral or written	Same as 2, but more structured. Specific information to be included in the answer is indicated.
2 (Simple, requires recall of classwork)	sunflower seeds	oral or written	Design an experiment to investigate effect of scarification on sunflower seeds. Basic recall of lab experiment (open-ended).
3 (Requires analytical thinking)	Spanish Needle seeds (Bidens pilosa); graph paper	written	Graph given data, analysis of experimental design, interpretation of data.
4	Spanish Needle seeds (Bidens pilosa)	written	Design an experiment based on a given table of data. Structure and design open.

ALTERNATIVE 1

PREPARATION

Purchase sufficient sunflower seeds (or other large seeds which appear to have hard seed coats such as corn or bean) so that each student can have a few seeds to feel and observe. Have the seeds ready to distribute prior to giving the evaluation.

ADMINISTRATION

Hand out some sunflowers seeds and allow students time to feel and observe the seeds. Then hand out the evaluation. This alternative gives much more structure and support to the students by telling them the parts of a valid experiment to be included in the experimental design.

Some students may wish to follow through with the experiment to test the effect of scarification on sunflower seeds. They should certainly be encouraged to do so. For teacher information, however, sunflower seeds do not have a hard seed coat in the biological sense, therefore, percentage of germination is not affected by scarification.

ECOLOGY EVALUATION 1 - EXPERIMENTAL DESIGN

ALTERNATIVE 1

Design an experiment to investigate the problem, "What effect does scarification have on the germination of sunflower seeds?"

1. What operations and procedures are needed to carry out the experiment? (You may use flow diagrams.)

2. What is your control?

3. How many replications are necessary?

4. What standards, if any, must be set for data collection?

ALTERNATIVE 2

PREPARATION

Purchase sufficient sunflower seeds (or other large seeds which appear to have hard seed coats such as corn or bean) so that each student can have a few seeds to feel and observe. Have the seeds ready to distribute prior to giving the evaluation.

ADMINISTRATION

Hand out some sunflower seeds to the students. The sunflower seeds are large seeds and appear to have a hard seed coat. Allow the students time to feel and observe the seeds, then ask them to design an experiment to investigate the following problem. Remind students they are to design, not carry out, the experiment.

"What effect does scarification have on the germination of sunflower seeds?"

ASSESSMENT

Depending upon the ability level of the class, the evaluation may be kept at the oral discussion level, or it may be written and discussed later. Students who have mastered the skills in Ecology Unit 1 Section A will be aware of the techniques and procedures needed to set up a valid experiment. For other classes or individuals, the teacher may have to assist them to note the important parts of a valid experiment. For most students, presenting their ideas via a flow diagram is a more efficient and quicker method than writing out all the details. In answering the question, assist the students if necessary to note that:

1. A problem statement must be included.

2. Experimental design must be changed somewhat from that of Topic 2, Scarification of Seeds. The seeds are too large to fit 50 of them into a small container like the one used previously. This will necessitate a change in design. The student may either use a large container, or fewer seeds per container. Students will have to decide how many seeds per container are enough.

3. Replications need to be made to validate results. The students will have to decide how many replications are enough.

4. A control must be included in the design to test any differences due to scarification.

5. Students must decide what standards, if any, must be set.

ALTERNATIVE 3

PREPARATION

If possible, collect some Spanish Needle seeds (Bidens pilosa) from around the campus so that each student will have a few seeds to feel and observe. Have the seeds ready to distribute prior to giving the evaluation. An alternative is to have students go out and collect their own seeds.

ADMINISTRATION

After the students have had an opportunity to observe the seeds, distribute the evaluation and have them answer questions given there.

ASSESSMENT

Depending on the ability level of the students and the type of graphing they did in class, either a bar graph or a line graph can be made. The data is recorded as the number of seeds germinated. If a graph of the percentage of germination is desired, the data must be converted by the students into percents. If you wish to test certain classes on the ability to figure percents, change the data in the table to a base 25 rather than 50 seeds per container, by dividing each of the data figures by 2. The graphs of the data should look similar to those given below.

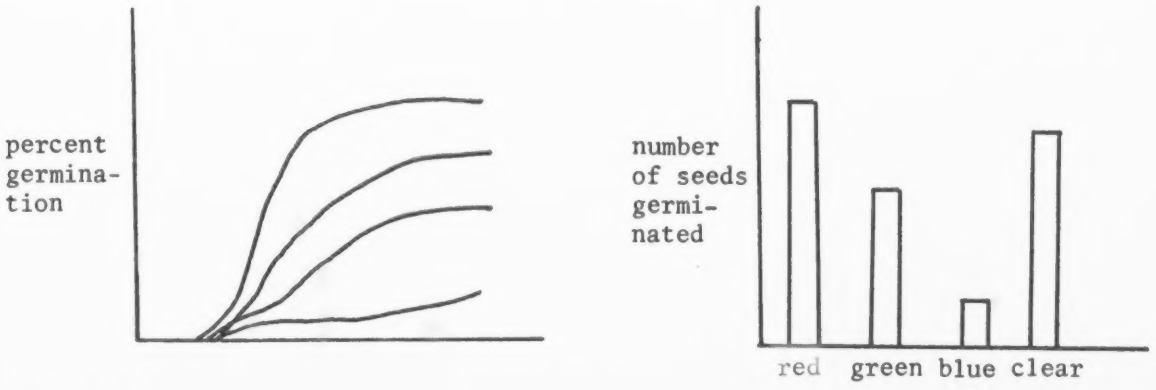


Figure 1 Germination of Spanish needle in colored light.

ECOLOGY EVALUATION 1 - EXPERIMENTAL DESIGN

ALTERNATIVE 3

An investigation of the effect of light on the germination of Spanish Needle seeds (Bidens pilosa) was done by a group of students. They set up greenhouses with 50 Spanish Needle seeds in each. The greenhouses all received the same treatment except for the color of the light to which they were exposed. The colors red, green, and blue were used. Two identical sets of experiments were run.

Table 1 Number of Spanish Needle Seeds Which Germinated under Different Colored Light (50 seeds/greenhouse)*

	Color of light or greenhouse	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
SET A	Red	0	0	8	36	40	45	47	47	47	47
	Green	0	0	1	5	20	20	23	27	27	28
	Blue	0	0	1	1	1	1	2	6	9	10
	Colorless	0	0	5	19	24	27	32	38	43	44
SET B	Red	0	0	15	36	42	42	42	44	45	47
	Green	0	0	4	8	13	13	15	22	23	24
	Blue	0	0	1	2	2	2	2	3	3	3
	Colorless	0	0	3	16	18	18	25	31	35	35

1. Graph the data.
2. What are the controls, if any, in this experiment?
3. What are the variables, if any, in this experiment?
4. What do you think the problem statement might be?
5. What conclusions, if any, can you make based on the data and the graphs?
6. Do you think this experiment is a good one? Why or why not?

*The data in Table 1 was collected by Gladys Kawano and Lori Yamamoto of Stevenson Intermediate School, Honolulu, Hawaii.

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ALTERNATIVE 4

PREPARATION

If possible, collect some Spanish Needle seeds (Bidens pilosa) from around the campus so that each student will have a few seeds to feel and observe. Have the seeds ready to distribute prior to giving the evaluation. An alternative is to have students go out and collect their own seeds.

ADMINISTRATION

The data in this alternative are based on an experiment done with Spanish Needle seeds (Bidens pilosa). If available, distribute Spanish Needle seeds to the students so that they can see and feel what the seeds are like. This alternative requires students to design an experiment based on a table of results of an experiment done on Spanish Needle seeds. The discussion which follows the evaluation should allow for a wide variation in ideas and techniques.

Distribute the evaluation which includes data on the effect of colored light on Spanish Needle seeds. Tell students only that two sets of identical experiments were run on the seeds. The data collected are shown in the table. Ask students to design an experiment which might have produced such data.

ASSESSMENT

Students should include the problem statement, materials needed, procedure, and a flow diagram of the operations. The students should also state any conclusions that can be drawn from such data.

ECOLOGY EVALUATION 1 - EXPERIMENTAL DESIGN

ALTERNATE 4

Design an experiment which might have produced the following data.

Table 1 Number of Spanish Needle Seeds Germinated under Different Colored Light (50 seeds/test)*

	Color of light	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
SET A	Red	0	0	8	36	40	45	47	47	47	47
	Green	0	0	1	5	20	20	23	27	27	28
	Blue	0	0	1	1	1	1	2	6	9	10
	Colorless	0	0	5	19	24	27	32	38	43	44
SET B	Red	0	0	15	36	42	42	42	44	45	47
	Green	0	0	4	8	13	13	15	22	23	24
	Blue	0	0	1	2	2	2	2	3	3	3
	Colorless	0	0	3	16	18	18	25	31	35	35

*The data given here was collected by Gladys Kawano and Lori Yamamoto at Stevenson Intermediate School, Honolulu, Hawaii.

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CLASS PROGRESS RECORD

Ecology Evaluation 1

STUDENTS	TOTAL		Can outline experimental procedures to investigate a question	Recognizes need for control	Provides for control in experimental design	Recognizes need for replication	Provides for replication in experimental design	Recognizes need for setting standards	Describes setting standards in experimental design	Selects appropriate graph scale	Properly labels and titles graphs	Can properly plot graph	Can interpret experimental data

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ECOLOGY EVALUATION 2

TEACHER'S NOTES

Unit 2, Sections A and B, deal with soil texture, evaporation, absorption, percolation, and capillarity of water in soil, and the effect of plant roots on soil. The following evaluation is designed to assess student understanding of these topics.

PREPARATION

Collect soil samples from a known geographical area on or near campus that students are likely to be familiar with. The samples may come from the lawn, near the parking lot, from a sandy part of the campus, from the CSA, etc. Try to get samples that are characteristic of different areas.

ADMINISTRATION

Distribute samples of the soils to students and allow time to observe and feel them. Distribute the evaluation and have students answer the questions.

ASSESSMENT

Questions 4 and 5 are extensions of classwork already done and are therefore more difficult for students to answer.

Some possible responses to the questions 2-4 may be:

2. Students may list any or all of the following: texture, absorption, percolation, capillarity, evaporation, plant roots, color, structure, fertility, tilth, erosion effects, temperature, mineral content, age, profile, and others.

3. The experiments may involve testing any of the likenesses and differences already listed. Students will have to decide whether to compare the soil samples in one, a few, or all of the categories. Depending on the ability level of the students, the teacher may have to assist some classes or individuals to note the following:

   a. Standards must be set for comparison of results.
   b. Replications must be made to support any conclusion.

4. Answers may vary as widely as there are students in the class. Some possible answers might be: for gardening, for farming, to investigate soil variation with organisms in the soil, for geological survey, for assessing land values, for land development, etc.

CLASS PROGRESS RECORD

Ecology Evaluation 2

STUDENTS	TOTAL		Can identify similarities and differences in soils 1	Can identify properties of soil such as texture, absorption, percolation, capillarity, etc. 1, 2	Can design a valid experiment to test soils 3	Can use flow diagrams to show procedures 3	Provides for control in experimental design 3	Provides for replication in experimental design 3	Sets standards in experimental design 3	Can identify practical applications of soil analysis 4	Can identify soil properties necessary for plant growth 5

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ECOLOGY EVALUATION 2

1. Either by referring to a map of the campus, or relying on your knowledge of the campus, predict where the soil samples you have been shown came from. Record your reasons for your predictions.

2. Describe the ways in which soil samples taken from different places might be

   a. alike.

   b. different.

3. Design experiments to see in how many ways soils from different places are

   a. alike.

   b. different.

   Include a problem statement, materials needed, and use a flow diagram to show experimental procedures. You need not carry out the experiment.

4. Of what practical use is the analysis of soil samples?

5. Considering your experience with soil in doing the plant propagation investigation, what kind of soil do you think would make a good garden soil? Explain your answer.

ECOLOGY EVALUATION 3

TEACHER'S NOTES

Unit 2, Section C involves the students in an investigation and measurements of humidity and the observation of clouds.

The evaluation suggested here takes on a more conventional test format, thus presenting students with a different type of evaluation than has been used in Ecology thus far.

This evaluation can be used to review ideas presented in class and to stimulate discussion. During the discussion, students should be urged to explain how they arrive at their answers, both conceptually and mathematically.

ASSESSMENT

For this evaluation there are "right" answers.

1. a. 100%, or high, or saturated
   b. rainy
   c. 50%, probably had stopped raining.

2. a. decreases
   b. decreases
   c. increases
   d. cannot have more than 100% humidity except under unusual circumstances.

Question 4 calls for more information than has probably been required thus far. Definitions for these terms are more fully developed in Physical Science Unit 2.

CLASS PROGRESS RECORD

Ecology Evaluation 3

STUDENTS	TOTAL		Can calculate relative humidity from a given set of data 1	Can identify how changes in relative humidity affect weather 2	Can describe how changes in temperature can affect relative humidity 2	Can identify instrument for measuring humidity 3	Can describe how a humidity measuring instrument operates 3	Can describe the relationships between water vapor, steam, fog, and clouds 4

ECOLOGY EVALUATION 3

1. A certain parcel of air at a temperature of 20°C can hold up to 18 g of water. The same parcel of air at a temperature of 6°C can hold up to 8 g of water.

   a. On Monday afternoon, the parcel of air contained 18 g of water at 20°C. The relative humidity was _____.

   b. By Tuesday morning, the temperature of the air parcel had dropped to 6°C. Describe what the weather was probably like on Tuesday morning.

   c. By Tuesday evening, the temperature of the air was still 6°C, however, the parcel of air contained only 4 g of water. What was the relative humidity of the parcel of air on Tuesday evening? How had the weather changed?

2. For each of the problems given below, write increases, decreases, or remains the same, in the blank space to describe what most probably happens as the temperature changes.

   a. The relative humidity of a given parcel of air is 100%. The temperature rises. The relative humidity _____.

   b. The relative humidity of a given parcel of air is 50%. The temperature rises. The relative humidity _____.

   c. The relative humidity of a given parcel of air is 50%. The temperature lowers. The relative humidity _____.

   d. The relative humidity of a given parcel of air is 100%. The temperature lowers. The relative humidity _____.

3. Describe or sketch one instrument for measuring relative humidity. Explain what effect humidity has on the instrument.

4. Describe or explain the differences, if any, between water vapor, steam, fog, and clouds.

ECOLOGY EVALUATION 4

TEACHER'S NOTES

Unit 2, Section D involves the investigation of weather, weather mapping, and climate.

PREPARATION

In the Reference Booklet on Weather Instruments, there are seven evaluation/discussion questions which deal with standardization and use of rain gauges. Refer to those questions and choose one or more which may be added to the evaluation on the next page.

MODIFICATION

1. A modification of question 2 which you may wish to use would be to add a Point B somewhere else on the map, for example over the city, and ask students to describe the effect of each on the listed topics on Point B. Students may then compare the effects on the two points.

2. Another modification to the question would be to ask not only the effect on rainfall and temperature, but also the effect on such things as wind speed, wind direction, humidity, barometric pressure, particles in the air, etc.

CLASS PROGRESS RECORD

Ecology Evaluation 4

STUDENTS	TOTAL		Can describe standards which must be set in data collection 1	Can describe the effect of tradewinds on weather and climate 2	Can describe the effect of altitude on weather and climate 2	Can describe the effects of large bodies of water on weather and climate 2	Can describe the effect of large forest areas on weather and climate 2	Can describe the effect of cities on weather and climate 2

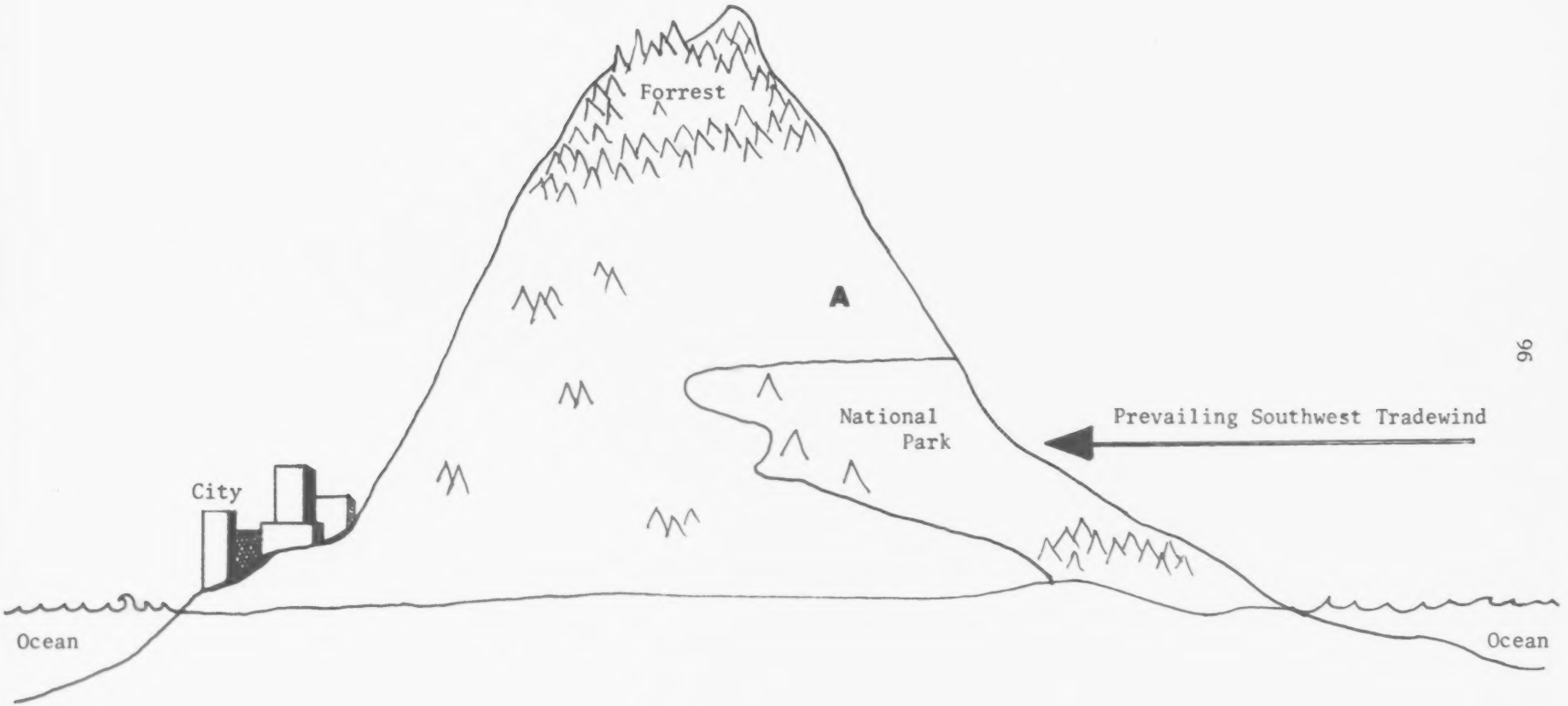
ECOLOGY EVALUATION 4

1. A group of students want to study the rainfall and temperature patterns of a valley between their school and a neighboring school. They have decided to share the labor by having a class from each school work on the project. What standards must be agreed upon by the classes in both schools before they can use and compare their data?

2. The diagram on the next page represents a volcanic island called Fastovia. The Weather Service of Fastovia has established a weather station at Point A on the diagram. Predict what effect, if any, each of the following would have on rainfall and temperature measurements at Point A.

   a. Gentle prevailing southwest trade winds
   b. Elevation
   c. Surrounding ocean
   d. Presence of the National Park
   e. Presence of the city
   f. Forests

VOLCANIC ISLAND OF FASTOVIA



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ECOLOGY EVALUATION 5

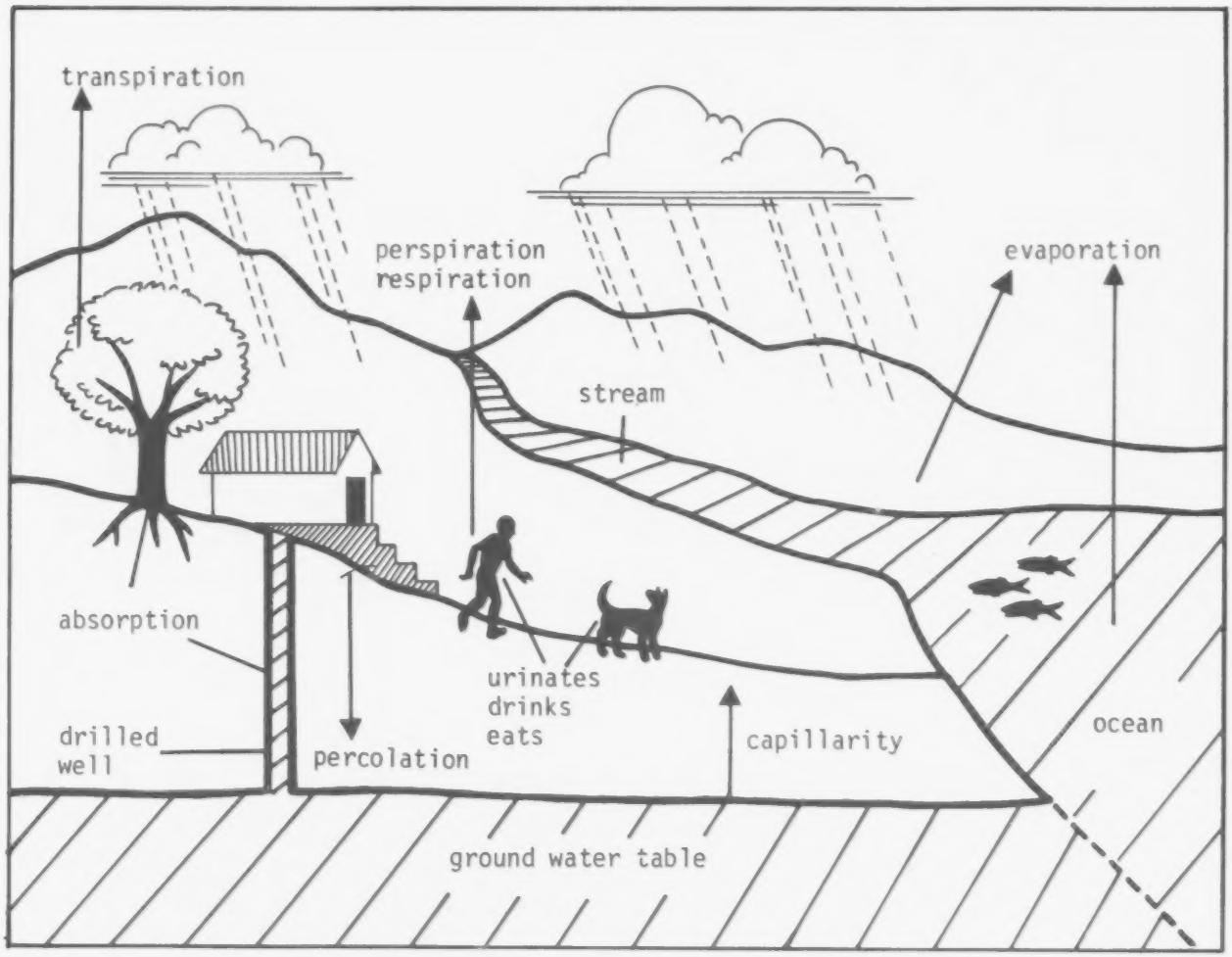
TEACHER'S NOTES

Unit 2, Sections E and F involve the students in the investigation of rain and transpiration. On completion of these investigations, students should be able to trace the water cycle.

ASSESSMENT

Two questions regarding transpiration are included in the evaluation.

A possible answer to question 3 on tracing the water cycle is shown below. Other variations are also possible. List processes.



CLASS PROGRESS RECORD

Ecology Evaluation 5

STUDENTS	TOTAL		Can describe transpiration 1	Can describe stomates and their functions 1	Can identify a problem for experimental investigation 2	Can design a valid experiment to investigate transpiration 2	Can make a proper flow diagram of experimental procedures 2	Can show in diagram form the water cycle 3	Can identify the changes of state involved in the water cycle 3	Can identify the processes involved in the water cycle 3

ECOLOGY EVALUATION 5

1. Franky does not believe that water actually comes out of leaves and goes into air. She says she cannot see the water so it cannot be there.

   a. How does water get out of the leaves?

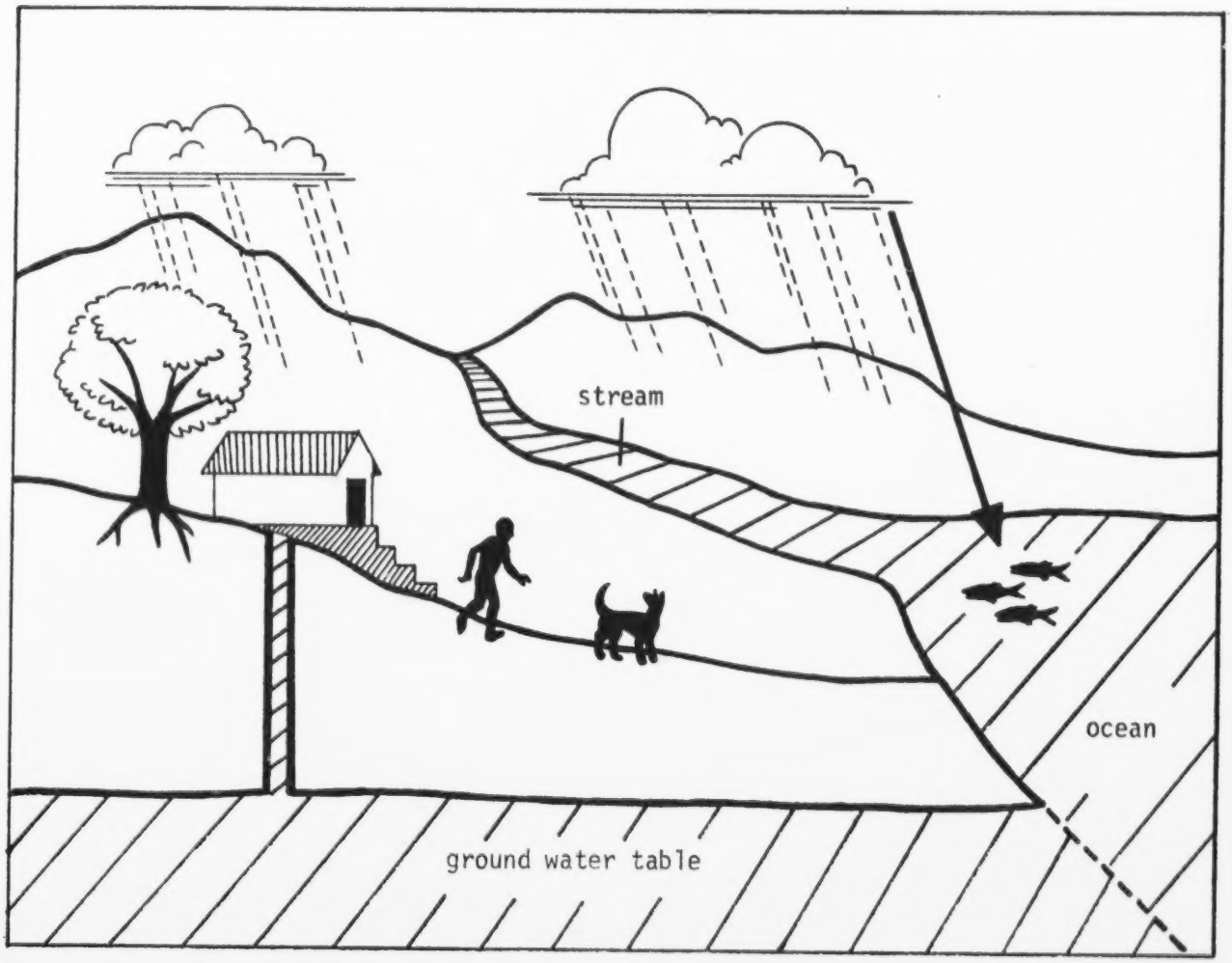
   b. Describe how you can show Franky that water comes out of the leaves.

2. Don thinks that the wind affects the rate of water loss from Croton leaves. His hypothesis is that as the wind speed increases, the rate of transpiration will also increase. However, Don does not know how to test his hypothesis.

   a. Describe the equipment and describe an experiment which will test Don's hypothesis.

   b. Be sure to include the problem statement, materials needed, and a flow diagram of the operations.

3. Below is a sketch of an environment. The arrow drawn from the cloud toward the ocean represents precipitation over the ocean. Draw other arrows going to or from the symbols on the diagram to show how water flows through this environment. Label each arrow with the process taking place. You may add more symbols if you wish.



ECOLOGY EVALUATION 6

TEACHER'S NOTES

Unit 4 involves the students in the study of ecology of the Class Study Area. This includes mapping, map interpretation, sampling, and open-ended ecology investigations.

ASSESSMENT

Possible answers to the questions include:

1. a. ¼ or 25%
   b. 1/8 or 12½%
   c. in the forest, or lower left corner, or SW corner, etc.
   d. similar answers as in c

2. Selective sampling, then random sampling using nets or capture-recapture can be used to sample the fish population, or other student ideas.

3. To count the lizards, count the entire population, or use effects sampling, or capture-recapture, or other student ideas.

4. a. The density of the thistle population is 2 thistles/km^2 or 2 thistles/4 cm^2.
   b. The frequency is 100%.

5. The river flows toward the west, or east to west. The contour lines show elevation. Water flows from higher to lower elevation.

CLASS PROGRESS RECORD

Ecology Evaluation 6

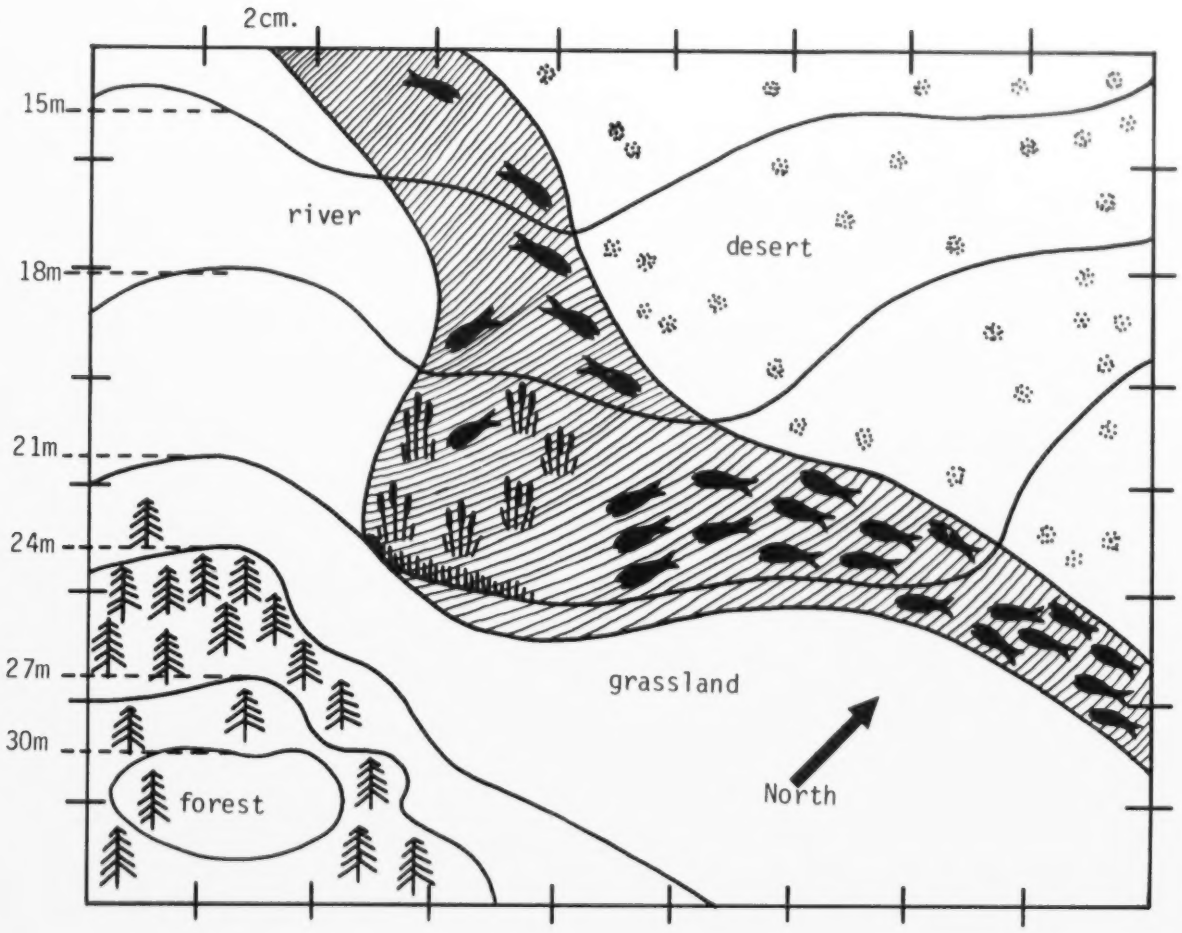
STUDENTS	TOTAL		Can identify percent cover on a map 1a	Can identify highest elevation on a contour map 1b,c	Can identify steepest area on contour map 1d	Can describe appropriate population sampling and techniques 3	Can calculate population density 4a	Can calculate population frequency 4b	Can identify direction of water flow on a map 5	Can give evidence for description of water flow 5	Can design a valid experiment for investigation of a field ecology problem 6

ECOLOGY EVALUATION 6

Bel w is a map of a FAST field. Study the map, then answer the questions which follow.

Scale: 2 cm = 1 km

Key:
- thistle patches
- forest
- schools of fish
- reeds
- grasses



1. a. Approximately what proportion of the mapped area does the desert cover?

   b. Approximately what proportion of the mapped area is forest?

   c. The highest point on the map is _____.

   d. The steepest part of the mapped area is _____.

2. The ovals in the water represent schools of fish. What sampling techniques would you use to sample the fish population? Why?

3. Some very rare lizards are known to exist in the desert. What sampling techniques would be best to count them? Why?

4. The circles in the desert represent patches of thistles. If the map of the desert area is marked off in a 4 cm^2 grid, ($1km^2$)

   a. what is the density of the thistle patch population?

   b. what is the frequency of the thistle patch population?

5. In which direction does the river flow? How do you know?

6. An area of the grassland is shaded by the forest most of the day. Sam thinks that the kinds of grass in the shaded area may be different from those in the open area. Design a field investigation to test Sam's hypothesis. Include a problem statement, materials needed, and procedure.

OTHER ECOLOGY EVALUATION

The following problems are designed to evaluate student progress.

Ecology Problems 4 and 5 Oral and Written scientific reports.
Oral and written reports are suggested for investigations 3, Plant Propagation and 26, Animal Care. In evaluating students' work, assess the following: (1) the actual work done in carrying out the investigation, (2) the experimental design used, (3) the content of the oral and written presentations, and (4) the presentation of the oral and written reports.